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Ideals of the Telephone Service

A Tribute to the Memory of Alexander Graham Bell

Presidential Address Delivered at the Ninth Annual Meeting of the Telephone Pioneers of America

THIS is the Ninth Annual Meeting of the Telephone Pioneers of America, although our association is now entering upon its twelfth year. On account of the war, during three years no annual meetings were held. The Pioneers were then engaged in the great struggle to save civilization.

The membership of our association is made up not only from those who took part in the first development of the telephone, but also from those who have been in the telephone service for a period of twenty-one years. We have in the service tens of thousands of zealous men and women doing Pioneer work now, but because they lack in years, though not in achievement, they have not been enrolled. We and they are looking forward to the day of their formal admission. To these our fellow-workers we extend our greetings and our appreciations. In their hands, lies not only the future of our society, but the future of our art.

Our first meeting took place eleven years ago, at Boston, the birthplace of the telephone. At that meeting,

the inventor of the telephone, Alexander Graham Bell, was present and delivered to us an address which must always be memorable in the history of our Society. Today, we recall with peculiar sadness these words which he then spoke to us:

"This is a great day for me, the first meeting of the Telephone Pioneers of America and of the world. It gives me great pleasure to meet with you all today, and yet there is a feeling of sadness about it. I am the first telephone pioneer and my memory goes back to the very beginning, and I miss the faces I remember so well, the faces of the old pioneers whom I wish were here today.

* * * * *

"I feel it a little presumptuous on my part to try to speak of the telephone to telephone men. You have all gone so far beyond me. Why, the little telephone system that I look back upon, what is it compared to the mighty system that goes through the whole extent of our country today? It is to you that this great telephone development is due, and I feel that it behooves me to speak very modestly of the little beginning that led to this great end. I cannot tell you anything about the telephone. I cannot speak to you about undulating current, intermittent current, and pulsatory current. I belong to the past; you belong to the present."

Here stand revealed those lovable qualities of the great pioneer—generosity and modesty—which endeared him to us all. It is true, indeed, that he belonged to the past, though then he still belonged to the present. Now he belongs to the ages.

Alexander Graham Bell died on Wednesday, August 2, at the age of seventy-five, at his summer home in Nova Scotia, near Baddeck. He was buried on August 4, at sunset, on the summit of a mountain overlooking the Bras d'Or Lakes. As a tribute to his memory, telephone service was suspended for one minute throughout the United States and Canada during the simple ceremony.

The manifold activities of his life, devoted to the service of mankind, would require volumes to portray. The medals and other honors which he received from learned societies, his honorary degrees from Universities at home and abroad, and special recognition by Governments, all testify to the esteem in which he was held. His scientific researches in the field of heredity and eugenics, his experiments in aeronautics, his work in improving the phonograph, and in teaching the dumb to talk, and his invention of the photophone, reveal the scope of his mind. This record alone is enough to insure his fame, but his discovery of the method of transmitting articulate speech by electricity, and his invention of the apparatus to do this marvel, have placed his name among the immortals.

Dr. Bell was born March 3, 1847, in Edinburgh, Scotland. He went to Canada in 1870, and the next year, at the age of twenty-four, he removed to Boston. After introducing into New England schools improved methods of teaching deaf mutes to speak, he was appointed Professor of Vocal Physiology in Boston University.

In his spare time, he conducted experimental researches in electrical wave transmission. He was assisted financially in these experiments by two gentlemen of Boston, Thomas Sanders and Gardiner Greene Hubbard. By the summer of 1874, he had worked out his theory that the transmission of speech by electricity could be accomplished by producing "electrical undulations similar in form to the vibrations of the air" which accompany the original words or sounds. In spite of great difficulties and discouragements, he succeeded in reducing his theory to practical form, when, at Boston, in the summer of 1875, he invented a telephone which faintly transmitted parts of words and even entire words.

Mr. Thomas A. Watson, Bell's assistant, relates that it was on March 10, 1876, over a line extending between two rooms in a building at No. 5 Exeter Place,

Boston, that the first complete sentence was ever spoken and heard through the electrical telephone. It was spoken by Bell and heard by Watson, who recorded it in his note book at the time. It consisted of these words: "Mr. Watson, come here; I want you." Thus the telephone was born.

After completing his fundamental invention, Bell in a remarkable document predicted with amazing foresight the telephone system of the future. He also invented the photophone which was the first method of transmitting speech by electricity without wires, and the induction balance and the telephone probe for which he was awarded the honorary degree of Doctor of Medicine by the University of Heidelberg. To his successors in the laboratories in which he was the original worker, he left the further conduct of telephone research and development.

Turning to other departments of science, he displayed his remarkable intellectual gifts by the fruitful researches which he conducted. In his work on behalf of the deaf, which he continued to the end, is revealed a dominant motive in his life.

To Bell was accorded a privilege so often denied to those who have advanced the world by their discoveries—he lived to see the triumph of his great idea. When the first sentence was transmitted, the public regarded the telephone as a scientific toy. Then, the telephone plant of the entire world could be carried in the arms of a child. Today, vast telephone systems of intercommunication have been developed, extending the spoken word among the peoples of the nations.

The advances of the telephone art made by the successors of Bell were always a source of great satisfaction to him. Some of these, epoch-making in their nature, gave him special gratification.

On January 25, 1915, the transcontinental line, spanning Bell's adopted country from ocean to ocean, was in the presence of dignitaries of state and nation, dedicated to the public service. This was a day of

triumph for Bell, for, using a reproduction of the original instrument, he once again spoke the memorable words, "Mr. Watson, come here; I want you." But this time Bell was at New York, and Watson who heard him with perfect ease, was three thousand miles away in San Francisco.

Another advance attained the greatest distance over which the transmission of speech had ever been achieved. Early in the morning of September 30, 1915, words were spoken through a radio telephone at Arlington, Virginia, to the Hawaiian Islands where they were plainly heard. But, as if to proclaim the telephonic conquest of time as well as space, the words reached these distant islands of the Pacific when it was there still the evening of September 29.

There yet remained to be realized that prophetic dream of the telephone pioneers—the bridging of the Atlantic by the human voice. But the day of its fulfillment was not far off for on October 21, 1915, during the dark days of the war, speech was for the first time in history successfully transmitted across the Atlantic Ocean. This was accomplished by the radio telephone, which carried the words spoken at Arlington, to the Eiffel Tower at Paris.

The last memorable telephone development destined to occur in the life of Bell will always be associated with a great historic occasion. At the burial of the Unknown Soldier at Arlington, on November 11, 1921, the voice of President Harding, by means of the new loud speaking amplifiers, was easily heard by the great concourse of a hundred thousand people about him, even by those in the most distant parts of the vast cemetery. Corresponding multitudes numbered by tens of thousands, at New York and San Francisco, heard over the wires every word spoken by their Chief Magistrate, as clearly as though in his actual presence. These distant multitudes heard also the invocation of the Chaplain, the music and the hymns, and the words of the commitment service used by the Bishop at the grave. They joined with each

other and with those at the cemetery in the singing of the hymns, and they united with the President in reciting The Lord's Prayer with which he closed his address. They heard in amazement the salvos of artillery fired at the grave, and even those on the shores of the Pacific caught the loud reverberations thrown back by the Virginia hills. At the end, in profound silence and with heads bowed in sorrow, they listened to the plaintive notes of the trumpet sounding the soldiers' last farewell.

On that day, the achievements of science imparted a mystical power to the most solemn national ceremony in the history of America. This ceremony, its deep significance so enriched by the art of Bell, we can now believe contained an exalted sanction of the greatest of all the achievements of his life.

These are but some of the advances which have been made in the first half century of the telephone art, which is now drawing to a close. They belong to the golden age of communications which has achieved the extension of the spoken word throughout both space and time.

But this golden age has not yet ended, and when we contemplate the possibilities of the future we discover that it has only just begun. It is to the future that we must now turn our minds and direct our endeavors. It is true that we Pioneers belong to the past, but it is equally true that we belong to the present. As individuals, we must all pass away, as did the First Pioneer; but our Association, the Telephone Pioneers of America, will continue to live. The greatest work which our society can do, is to exemplify the ideals of our service, and to transmit to its future members the splendid traditions of our art. It should be our purpose to encourage and to sustain among the men and women of the telephone system their ever-increasing zeal for the public service.

While it is beyond my power to put into words these ideals of our service, they already exist within your hearts and mine, where we all can feel, though I cannot express, their potency. These feelings which

form the mainspring of our actions, do not arise from mere wishful thinking, nor do they spring from an idealism which is disconnected from reality. They rest upon a solid basis of achievement, and represent the practical purpose of that great telephone system of intercommunication which bears the name of our First Pioneer.

It is interesting to note that the biologists were the first to appreciate the peculiar importance of electrical communications in the social organism, and to Herbert Spencer, writing more than fifty years ago, we are indebted for some analogies which have not yet been sufficiently studied either by the biologist or the engineer. In tracing the analogy between the telegraph system of his day and the nervous system of the animal organism. Spencer expressed the view that probably when the then rudimentary telegraph systems were more fully developed, other analogies would be traceable. This development has already been provided by the telephone art, and national telephone networks have now become a vital part of the social organism. I believe that the study of these networks from the standpoint of biology is destined to yield important results, and indeed, that an investigation of the remarkable developments of the automatic machinery used in modern telephone switchboards might even throw light on the mechanism of the mind itself.

Scientists have long been studying the theory that man has advanced to his present high estate by upward progress in the biological scale from a microscopic speck of protoplasm forming the biological cell or unit of life. They have pictured him as composed of countless millions of these living creatures forming an organic entity marvelously designed, each cell performing its allotted part in that exquisite division of labor which characterizes this biological State.

We commonly compare a nation to a complex living organism. "We speak of the body politic, of the functions of its several parts, of its growth, and of its diseases, as

though it were a creature. But we usually employ these expressions as metaphors, little suspecting," as Spencer says, "how close is the analogy, and how far it will bear carrying out. So completely, however, is a society organized upon the same system as an individual being, that we may almost say that there is something more than analogy between them."

Each cell has its allotted and specialized work to do. Each cell must be fed, and live, and grow. Sustenance must be obtained, prepared, and assimilated, and the waste removed. The physiological mechanisms for doing these things and many other things besides, have their striking counterparts in the structure of organized society, and furnish instructive material for the philosophic student. But to us of the telephone art, the most marvelous thing of all is the nervous system, that inconceivably complex communication network, by which the activities of both individual and society are regulated and without which paralysis and death would result.

We are told that the cells which compose the nervous system are the latest to appear in the upward march of the organism, and that the degree of their complexity and the extent of their differentiation furnish a criterion for determining the stage of progress which has been attained. Because of the high function, almost spiritual in its nature, performed by these nerve cells, they have been called the noble cells. I have long felt and often expressed the feeling that because of this the workers in the telephone art are engaged in a high calling, building up the noble cells which constitute the nervous system of the Nation.

As in the animal body, these cells were the latest to appear, so in the structure of organized society the highest form of electrical communication, the telephone, is the latest to appear—it comes only at the stage of higher development. And again as in the animal body, the stage of development of the nervous system is an index of its place in the evolutionary series, so I believe it will be found in any social organism that the degree of

development reached by its telephone system will be an important indication of the progress which it has made in attaining coordination and solidarity.

The use of the spoken word to convey ideas, distinguishes man from all other created things. The extension of the spoken word by means of electrical systems of intercommunication serves to connect the nervous system of each unit of society with all of the others, thus providing *an indispensable element* in the structure of that inconceivably great and powerful organism which many biologists feel is to be the ultimate outcome of the stupendous evolution which society is undergoing.

That such an organism, thus so magnificently conceived, would be the outcome of the higher evolution of man, I have long believed; but its form and the nature of its functioning, I could not imagine. But the great work of Trotter, who has studied the gregarious instinct in the lower animals and in man, permits us to contemplate this evolutionary entity from a new point of view. He has pointed out that nature, having failed in her giant organisms, in which so many individual cells were crowded into such animals as her giant lizards and the mammoth and the mastodon, was to try a new method which was to dispense with gross physical aggregations of cells combined into one body. He points out that the flock, the herd, the pack, the swarm—new organizations—were to be devised by nature, and to flourish and range throughout the world, and that in one of these new organizations, human society, the individual man is still to be regarded as the unit, but not constrained as is the cell in the animal body, but free to move about, the mind alone being incorporated into the new unit by the marvelous power of intercommunication. He shows that the power of these organisms depends on the capacity for intercommunication among their members, and that this power expands until the limits of this intercommunication are reached.

How fundamental, electrical communication systems

are, in the tremendous evolution of the human race which is now being manifested in the organization of society, and how vital to the welfare of mankind is the daily work of telephone men and women everywhere, is being made more and more apparent by the discoveries of the new school of biologists.

Speaking always of communication in its broadest meaning, but emphasizing the importance of speech, Trotter says: "The capacity for free intercommunication between individuals of the species has meant so much in the evolution of man, and will certainly come in the future to mean so incalculably more, that it cannot be regarded as anything less than a master element in the shaping of his destiny."

And again, in speaking of human society as a gregarious unit, he says: "The ultimate and singular source of *inexhaustible* moral power in a gregarious unit is the perfection of communion amongst its individual members."

As long as intercommunication was limited, he tells us, the full possibilities of nature's new experiment were concealed. But at length appeared man, a creature endowed with speech, in whom this capacity for intercommunication could develop indefinitely. "At once a power of a new magnitude was manifest. Puny as were his individuals, man's capacity for communication soon made him master of the world. . . . . In his very flesh and bones is the impulse towards closer and closer union in larger and larger fellowships. To-day he is fighting his way towards that goal, fighting for the perfect unit which nature has so long foreshadowed, in which there shall be a complete communion of its members, unobstructed by egoism or hatred, by harshness or arrogance or the wolfish lust for blood. That perfect unit will be a new creature, recognizable as a single entity; to its million-minded power and knowledge no barrier will be insurmountable, no gulf impassable, no task too great."†

† "Instincts of the Herd in Peace and War"—W. TROTTER.

Here we have portrayed the forward march of humanity toiling ever onward to attain its goal. The realization that their wonderful art is destined to play such an important part in this final attainment, opens up a never-ending source of power and inspiration for telephone men and women everywhere. It adds a new dignity to their calling. Already, as we have seen, the human voice has been carried with the speed of light across the Atlantic Ocean, and across our continent, and far out into the Pacific; but still greater things are sure to come.

It is the mission of the Pioneers and their successors, and their associates among all the nations, to build up a telephone system extending to every part of the world, connecting together all the peoples of the earth. I believe that the art which was founded by Alexander Graham Bell, our First Pioneer, will provide the means for transmitting throughout the earth a great voice proclaiming the dawn of a new era in which will be realized that grandest of all our earthly aspirations—the brotherhood of man.

JOHN J. CARTY.

Notes on Radio

THE following notes may be of some help to those who are trying to gain a better idea of radio and what it means to the telephone business. The first part is intended to assist in forming a clear picture of the physical nature of both wire and radio transmission. The latter part is a brief discussion of the fields of use for which radio has been developed, or for which it is being considered.

Characteristics of Wire Transmission

It is undoubtedly the popular idea that in our wire circuits the telephone waves are inside of the conductors, somewhat in the manner that a liquid is inside of the pipe conducting it. This is a very incomplete picture. It is true that electrical currents are in the wires, but the energy of the electromagnetic waves is largely outside of the wires, and surrounds them. We must imagine these invisible waves, in the case of our open wire circuits, filling up all the space around the wires, and within a distance of several feet of them, and rushing along the circuit at a speed of many thousands of miles a second, but prevented from spreading and guided by the wires to exactly the place to which we wish the waves to go.

In these wire systems, the electromagnetic waves (except in the recent carrier systems) are transmitted just as they come from the telephone transmitter, that is, they have the same frequencies as does the voice which causes them. They consist, therefore, of constantly changing complex waves, made up of frequencies varying from perhaps 200 cycles or less to over 2500 cycles per second.

Characteristics of Radio Transmission

In a radio system, on the other hand, while electromagnetic waves are also used, these are transmitted

into wire arrangements which we know as "antennae," so designed that a part of the waves become entirely detached from the wires and spread out in all directions, with no wire guides whatever, and limited in spreading only by the surface of the earth and perhaps also by layers of the upper atmosphere which have such electrical characteristics as to reflect them back.

Thus, in our radio systems, we have no line problems. We have acquired, however, several new sets of problems. I refer to (1) putting the voice waves into such a condition that they may be radiated into space and received from space, (2) separating the different radio messages from each other, and (3) the problems arising from the transmission characteristics of the space through which the radio waves travel.

Our ordinary telephone waves do not radiate appreciably from our circuits, partly because they are of too low frequency to be effectively sent out from structures of any ordinary size, and also because our wire circuits are not of a form which radiates easily. However, if these waves were liberated into space, they would travel just as well, and in fact somewhat better than the higher frequencies used in radio. Supposing they could be liberated, however, it is evident we would be met by the difficulty that all of our messages would interfere one with another, since they would all have the same range of frequencies, and since radio waves spread out in all directions.

The above difficulties are overcome in radio by generating a high frequency current for each message we wish to send, and causing the voice currents to control the magnitude of the high frequency waves that are sent out. It is a characteristic of high frequency waves that they may be radiated from comparatively small antennae systems. By employing a different high frequency for each of the telephone messages which we wish to send, we may at any receiving point separate any particular message from other messages which may be in space at the same time, provided the message we

desire is at a frequency differing sufficiently from the frequencies of the others. This separating is done by using so-called electrical tuning or electrical filter systems, which will let through the desired frequencies, but will stop all others.

It should be noted that in discussing radio, we refer to a message being sent out at a certain "frequency," or at a certain "wave length." All radio waves travel practically at the same speed, that is, the speed of light, which is 300,000,000 meters in a second. Now the distance traveled in a second is the frequency multiplied by the wave length. If we know the frequency, therefore, we can divide it into 300,000,000, and obtain the wave length and vice versa. The longer the wave length, therefore, the lower the frequency.

A good example of the difference in frequency required for separate messages is in the case of broadcasting. Until recently, all private broadcasting had been at a wave length of 360 meters, which is a frequency of about 830,000 cycles per second. It has now been decided to permit broadcasting simultaneously at a second wave length of 400 meters, which is a frequency of 750,000 cycles per second. If the waves were any closer together in frequency than this, it would not be possible, in some sections, for many of the present types of receiving sets to listen to the entertainment being sent out on one without also overhearing the other in sufficient amount to cause interference. The number of simultaneous messages, therefore, is limited by the degree to which the receiving sets can pick up one message and separate it from all others, and by the total range in frequencies which can be used in radio.

"Message Capacity of the Ether"

In discussing radio we commonly think of space as being filled with a medium called the "ether," and that it is this medium through which the electromagnetic waves are transmitted. There is considerable question

whether this is a proper physical picture, but it is anyhow a convenient manner of speaking. We should note, however, that if there is an "ether," the electromagnetic waves which we employ in our wire systems are transmitted through it just as truly as are the radio waves. With wire transmission, however, the electromagnetic waves travel through, and disturb only a relatively small region in the ether immediately surrounding the wires, whereas the radio waves disturb the ether for a very large region extending in all directions from the transmitting station.

We sometimes hear in radio the expression "message capacity of the ether." By this is meant the number of simultaneous radio communications that can be carried out in any region without interference. Evidently this depends greatly on the locations of the stations, on the type of apparatus used, and on the amount of interference permitted. Roughly speaking, however, it can be said that if the entire range of frequencies which have been developed for radio could be applied to radio telephony, it would be possible with the type of sets in general use to establish perhaps twenty-five simultaneous non-interfering two-way channels in any given region. In view, however, of radio telegraphy and radio broadcasting, of the radio compass and beacon stations which the government is establishing, and of the setting aside of wave lengths for military purposes, difficulties have already arisen in obtaining non-interfering wave lengths.

The radio conference which was brought together by the Department of Commerce to consider the matter recommended an allocation of wave lengths which, if carried out, would leave the radio telephone situation as follows:

For the ship-to-shore business, a range of frequencies is allocated which would permit two simultaneous conversations to be carried on in any one region, by making use of the best methods which have been developed in the art. This space, however, is not set aside exclusively for telephone service, but may also be occupied with

certain types of ship-to-shore telegraph. This might seriously interfere with the telephone service.

For trans-oceanic telephony no space was definitely set aside, although a range of frequencies was designated which would be sufficiently wide for one conversation, and it was recommended that tests of such transmission be permitted in this range.

For connection between fixed points, there were set aside two narrow frequency bands. These are at wave lengths best adapted for distances of several hundred miles. Each of these, with a small amount of further development work, could be made to carry a single conversation. They are not assigned exclusively to telephony, and so may be interfered with by telegraphy.

In each of the above cases, we have in mind two-way communication which could be connected into the wire system so that the radio would be an extension of the wire service, and without the necessity of the talkers using "push buttons" or other mechanical contrivances for switching their sets from the talking to the listening condition. The present art requires two wave lengths for such a radio communication, since the same wave length cannot ordinarily be used for each of the two directions.

Comparatively liberal provision was made by the committee for broadcasting purposes. Space was set aside in the general region in which broadcasting is now being done, permitting at least four simultaneous broadcast channels with present sets in the districts along the coast. This could be increased by at least two in the interior of the country by using, in addition, wave lengths which along the coast are employed in marine telegraphy. Furthermore, a space was set aside using much shorter wave lengths, in which several more broadcast stations could work, although these wave lengths would probably be less satisfactory for such service. The above is in addition to several frequency bands set aside for government and other official broadcasting.

It is evident that the above does not give much room in which radio telephony, aside from broadcasting, can develop. However, methods have been worked out theoretically, and to some extent in practice, by which it would be possible to increase the message capacity by several times. Such systems bring in considerable complexity and expense, and these increase rapidly as the channels are crowded closer together. With developments along this line, however, and with the further developing of shorter wave lengths than are now in use, we believe that the radio message possibilities can be increased sufficiently to take care of the services which require radio.

Transmission Characteristics of the "Ether"

Radio transmission is generally more variable than is wire transmission. This depends, however, largely on the wave lengths employed, and the distances covered. As an example, the power received from the usual type of broadcasting station at a distance of 30 miles is usually fairly constant. At 200 miles, if the distance is over land, the power received may vary hundreds of times within a few hours, or even within a few minutes. For longer distances the amount of variation rapidly increases.

Radio transmission over water is much less variable than over land. The amount of variation increases rapidly as the wave length is shortened.

Perhaps the most unhappy feature of transmission through space is the well-known "static." This appears to come from lightning and other electrical disturbances in space, and varies tremendously in volume from summer to winter, from day to day, and from hour to hour. Tests made at a point in northern New Jersey for long wave lengths show the average static at that point this summer about 50 times as great in power as the average static last winter. Variations of 25 times in static power were recorded within single days. As it is generally possible with modern receiving sets to amplify the received signals to the point where static interference

becomes so loud that further amplification is useless, this large variation in the static means a large variation in the distance to which the station may be heard.

It is because of these great variations in transmission and in static that it is nearly impossible to state the "range" over which a station may be heard. For example, under favorable conditions, a broadcasting station in the vicinity of New York has been heard far out on the Pacific Ocean. Under unfavorable conditions, the same station could not be heard satisfactorily at a 30 mile distance.

Directivity and Secrecy

Directivity in radio consists in the use of an antenna system so arranged that it does not radiate equally in all directions, but sends out or receives very much better in the direction of the station with which it is operating than it does in other directions.

The advantage of directivity at the transmitting end is a saving in power, since a larger percentage goes in the desired direction, and an increase in the degree of privacy of the message, since fewer stations will be in the region where it can be effectively picked up. A large difficulty here is that it is a physical law that it is not possible to devise a radiating system which will be efficient and which will also give sharp directivity unless the antenna structure is large compared to the wave length. As the radio waves which are generally in use are comparatively long (for example the usual broadcast waves are over 1000 feet in length, and the longest trans-oceanic radio telegraph waves over ten miles), it is not possible, without large expense, to give such waves more than a small degree of directivity at the transmitting station. In receiving systems, however, efficiency is not so important, as it can be made up to a considerable extent by amplifiers, so that a moderate degree of directivity at the receiving end can be frequently employed. This has the advantage of cutting down the amount of disturbance from static or from other

stations which may be coming in from directions other than that from which the desired message is being received.

Reports have been given out of tests carried on in England covering directed radio system with 15 meter wave lengths (20,000,000 cycles) and giving a much greater degree of directivity than with the usual wave lengths. There is considerable question, however, as to the usefulness of so short wave lengths, in view of the readiness with which they are absorbed.

Various means have been proposed for giving some degree of secrecy to radio telephone messages. These have depended generally on some action at the sending point, such as distortion of the voice waves, adding a noise frequency to them, continuously varying the wave length on which they are sent out, or similar propositions which would make it difficult for them to be picked up and understood. At the desired receiving point these systems depend on arrangements for removing the distortion or noise, or compensating for the changing wave length. While it is undoubtedly possible to devise a secret radio method which it would be practically impossible to tap, it would involve so great complication as to make it unsuitable for general use. Other systems have been developed which, while not "secret" are "private," in that they could be tapped only by those intending to do so, and using apparatus not generally owned by the amateur. Even with such systems, however, the complication and expense of any so far developed are larger than radio services can generally afford.

With this general discussion of radio, it will be interesting to consider some of the fields for which radio has been developed or considered.

Telephone Service to Ships or Other Moving Vehicles

A radio station was established at a point in New Jersey, and radio connections set up to a ship at sea through this station and then by wires to points as

distant as San Francisco and Los Angeles. In some of the tests, connections were established simultaneously to two ships and to a third land station. The nominal range of the station is considered to be 200 miles. Under favorable conditions, it has talked to a ship 1600 miles distant. Local conditions in summer may interrupt the service at distances less than 200 miles. The ultimate range given the station must, of course, depend on commercial requirements as well as the technical questions involved. Since the course of the trans-oceanic liners parallels the coast for a considerable way, it would be possible to reach such ships after they are out of range of a New Jersey station, by other stations on the coasts of New England.

A paper giving technical details of this system is in preparation, and will be published during the winter. At the present time, no further development work is being done on this system, awaiting the working out of the commercial problems which are involved in it.

Another development now being considered and which may be undertaken is a short range telephone system for use around the important harbors. This might be of considerable importance to the railroads and other companies operating tug boats, as it would permit the tug boat dispatchers to keep closely in touch with their craft, thus more efficiently keeping them in use. It is possible that no wave length assignment can be found for this service in the range now generally used for radio, and it will be necessary to go to shorter wave lengths.

Radio is of peculiar importance to airships, in that it furnishes a means by which they may be guided to their destinations. If they ever become of importance from a passenger or express-carrying standpoint, they will bear a relation to the Bell System similar to that of the ships at sea.

Another use of radio telephony which may ultimately be made is that of connection to moving trains. This is entirely a feasible proposition, but the cost of develop-

ing, setting up and operating such a system at present would, we believe, be too large in comparison with the probable amount of service which would result.

Radio Across Natural Barriers

Perhaps the most spectacular service for which radio will probably be applied in the future is the connection of the wire telephone system in America with the wire telephone systems in Europe and in other continents. Communication over such distances was shown possible by the tests of the Bell Telephone engineers in transmitting from Arlington to Paris and Honolulu in 1915. Large developments have been made in the art since that time, but considerable further work remains to be done before such a system can be established and operated at an annual charge sufficiently low to justify it commercially. There may also be difficulty in obtaining suitable wave lengths.

The Catalina Island system was the first radio telephone system to go into regular commercial use. It spans a 25 mile gap of water between the mainland near Los Angeles and Catalina Island. The details of this installation have already been published in the Proceeding of the Institute of Radio Engineers for December, 1921. It is the only case, at least in so far as information has been published, in which radio is furnishing a commercial service, and meeting in both transmission and signaling, but not as regards secrecy or economy, the ordinary requirements of wire service.

There are undoubtedly a large number of other cases in this country where radio will be used for establishing connections with districts to which it would be difficult or impossible to maintain wires. This will probably not be done on any large scale, until radio apparatus, by further development has been somewhat simplified and cheapened.

In many of the cases where radio will be used for reaching outlying points, the necessary reduction in

cost to prove it in will be obtained by making use of systems which do not meet the requirements of ordinary wire systems, but which will be sufficiently good for the limited service required by these points. For example, in one case recently considered it was thought satisfactory for the system to operate merely between a pair of telephone sets, one at each terminal, with no signaling devices whatsoever, and with communication carried on only for a few hours each day, and then at appointed times.

Broadcasting

A service for which radio, by its inherent nature, is particularly fitted, is that of broadcasting music, news, etc., to a large number of people who can listen to it by means of comparatively simple receiving sets. This type of system has become so thoroughly known as to require no explanation here. It is not a two-way service, and is not, therefore, of the same type as the usual telephone service. In this case the usual difficulties with radio of lack of secrecy and of spreading out over a large territory are the particular features fitting it for broadcasting economically over a wide area.

Telephone Service for Rural Communities

While, from the inherent nature of radio, it is entirely absurd to consider it for carrying on the usual telephone service in place of wire systems in districts which are well developed in population, we have attempted to determine whether it could be developed to give telephone service at a sufficiently low cost to find a field in very sparsely settled country districts.

In this connection, it should be pointed out that radio is purely a method of transmission of messages. In giving telephone service, it is necessary that we not only have means of transmitting our messages, but also means of connecting the transmitting channels together, so that any two subscribers may be permitted to talk. This is the function of the central office, and of the

operators who are employed there. Radio in no way avoids the necessity for this switching function.

As in the case of a multi-party wire line, it would be possible to arrange with radio so that a small group of subscribers could directly connect with each other. This, however, would not relieve the necessity of their being able to connect through a central office into the wire system, in order to reach more than a very restricted district.

A radio system, for connecting together a group of farmers and connecting the group to a central office, would need to include transmitting and receiving apparatus, and also the necessary power supply and calling devices, in addition to ordinary substation apparatus. Since a part of the apparatus would need to be continuously energized to receive signaling, tube renewals would be an important factor in the annual charges. It is evident that the radio art, as it now exists, cannot meet these requirements at anything like the $2.00 or $3.00 per month which the farmer usually pays for his wire service. Even with an optimistic estimate as to changes which can be brought about by development, it appears that in the rural field, as elsewhere, radio telephony will be limited to giving telephone service to comparatively isolated places, or under conditions which make the maintenance of wires more than usually difficult.

This does not mean, however, that low power radio transmitting sets, perhaps for use in combination with broadcast receiving sets, may not be used in considerable numbers as an amusement, permitting a number of people in a community to talk together as a group in the evenings or at other appointed times.

Some Conditions of Radio Development

The tremendous range of frequencies and energies employed in radio bring in many difficult but interesting technical problems. The frequencies employed vary

from around 50,000 cycles per second, which was used in telephoning to Paris and Honolulu, to frequencies of around 20,000,000 cycles per second, which have been employed in experimental radio work. The energy put into the antenna in the usual broadcasting radio station is about ½ kilowatt. In experimental telephone work, powers have been produced up to 100 kilowatts. These should be compared to about 0.1 watt, which is the maximum voice wave energy, under usual conditions, that is put on our wire circuits. At the receiving end of radio the powers are extremely small. At a distance of say 30 miles from a broadcasting station the usual amateur antenna will pick up perhaps a few millionths of a watt.

From the discussion which we have given it may be evident why it is that the development engineer has viewed radio with somewhat conflicting emotions. In perhaps no other part of the communication art have there been developed more beautiful technical methods or apparatus, or is there presented to him a more intensely interesting group of technical problems. It has opened up possibilities of giving new fields of telephone service, and the results which it has yielded and promises to yield in these fields appeal greatly to his imagination, as they do to that of the general public. Yet in perhaps no other field has the development engineer dealt necessarily with factors inherently so variable, or so little under his control, or has the development work yielded so little in results of practical commercial importance, as compared to the large expenditures made. Furthermore we know that to put radio telephony into such shape that it can give those services for which it is fitted will require that we continue intensive development for many years.

We have in mind, however, that with the constantly increasing demands for all types of communications the radio field, limited though it is in scope, may be expected to grow to considerable proportions. Furthermore we are watching with large interest the apparently great

appeal of radio telephone broadcasting to the general public. As already noted, the difficulties of radio for ordinary telephone work, that is, the spreading out over wide territory and non-secrecy are just the characteristics which are desirable in broadcasting. It may be that here there is a service in which radio telephony can assume considerable commercial importance, and much more than justify the large amount of development work which must be given to it.

O. B. BLACKWELL.

Service in the Making

IT is easy to define good service. From the viewpoint of the person desiring to talk, it consists in being able to reach promptly and without confusion any person desired and to talk satisfactorily and without interruption. To give good service, however, under present conditions is a difficult problem for the telephone companies and it becomes increasingly so year by year. It is also seldom appreciated how important a part the subscribers themselves play in the giving of telephone service. The person desired must have a telephone or be near one and he should answer a call promptly and courteously. He should have sufficient telephone facilities so that his lines will not be busy an undue portion of the time. If he has a private branch exchange, he should provide himself with competent operators, and if he does not answer the telephone himself, he should make provision for someone else to answer it properly. The calling subscriber should know how to make his calls, he should give the call accurately and clearly to the operator, and he should pay attention to her repetition. He should know how to use the transmitter and receiver so as to obtain the maximum efficiency from those instruments. He should know the significance of such signals as the audible ringing signal, and he should know how to signal the operator. Subscribers on party lines should refrain from interference with other persons on their lines who may be talking. If there is failure in any of these ways, the subscriber cannot receive satisfactory service although the telephone company does everything in its power.

Responsibilities of the Telephone Company

Coming to the responsibilities of the telephone company, mention should be made of the commercial department which handles the business relations with subscribers and which aids them in providing themselves with proper facilities to handle their telephone business. It must

also provide adequate directories so that the subscriber may know with whom he can talk and it must see that proper attention is given to all suggestions or complaints. However, the functions of the telephone company in giving service which are most commonly recognized are the provision of adequate plant properly maintained and the work of the traffic department which operates the plant and performs the actions necessary to connect one subscriber with another. It is with traffic work that this article is primarily concerned, but any description of telephone service which did not mention the important functions of the subscribers themselves and of the commercial, plant and engineering departments would be incomplete.

Problems of the Traffic Department

The most difficult problem of the traffic department is to maintain a satisfactory grade of service in the face of the continual increase in size and complexity of the telephone system. If we think of the early days of the telephone when subscribers were few and exchanges small and not inter-connected, the operating work seems simple as compared with the problems of today. I have in my office a copy of the first telephone directory issued in 1878 and it contains fifty names and no numbers. If you can now visualize such an exchange, the subscribers would call by name for the few other people having telephone service and it would be easy for an operator to handle the simple equipment and to make connection with one of the few lines which might be desired, to ring on that line and to take down the connection when the conversation was over. No record need be made of the call since the charges would be on a flat rate basis, and beyond ordinary attention and courtesy, the requirement for telephone operators would be simple. But conditions such as those are not found today and the present Bell Telephone System with its Connecting Companies consists of a vast and complicated

network, representing an investment of over two billion dollars and providing means for connecting any two of nearly 14,000,000 stations which may be located anywhere in the United States or in Cuba or in portions of Canada and Mexico.

The most complicated portions of the telephone system are naturally those in large cities and the surrounding territory, and in the case of the largest metropolitan area, New York, some 1,400,000 stations connected with 260 offices are located within a thirty-mile radius. Even in the case of a call between two subscribers in the same office, the work of the traffic department has long since changed from the simple conditions forty years ago and it becomes increasingly difficult year by year. Ten thousand lines and upwards of twenty thousand stations may be connected to a single office and to make even the simplest kind of connection in large cities, the services of at least two operators are now required. It would be physically impossible to make telephone connections now with the apparatus of early days and the development of improved telephone plant has more than kept pace with even the enormous growth in business. To provide good service to the subscribers, to assist the operators, and to aid in overcoming the increasingly difficult conditions, vast amounts of machinery are now provided, much of which is automatic in operation, and the operator of today must be skilled in the use of all this modern plant. For example, the operator no longer rings the called subscriber but that important action is performed automatically and mention might also be made of the methods for distributing the calls so as to assure prompt attention by any one of a group of operators, of the call circuits by means of which the operator answering the subscriber enlists the aid of another operator necessary to complete the connection, and of the many automatic signals by means of which the operator follows the progress of the call, advises the subscriber if the line is busy and attends his wishes if further action is necessary. By means of these automatic

signals the operator knows at all times, without listening on the connection, whether the subscriber is at his telephone, whether he has answered the call, whether he has finished talking and hung up and whether he wishes to make another call or attract the operator's attention for some other purpose. These automatic signals are transmitted over considerable distances and in the case of a call between New York and Philadelphia, for instance, one operator has control of the connection and is provided with just as complete signals from the subscriber at the distant point as from the one in her own city. Development work is now being carried on which will extend still further the distance over which automatic signals can be transmitted and thus improve the service and simplify the work of the operators.

Machine Switching System

There is a marked tendency to make the apparatus more and more automatic so that the subscriber himself can follow the progress of his call and know when a line called is busy or when the bell is ringing and the called subscriber is slow to answer, without waiting for the operator to advise him on these matters. The latest development in this direction is the machine switching system which is now coming into use and on which the general staff was working for a long time. This system calls for apparatus more complicated than any previously employed in telephone work but it provides means for the entire handling of a local call by machinery under direction from the subscriber. It might be thought that the introduction of the machine switching system would mean the gradual elimination of the telephone operator, but such is not the case. The growth of the business is so rapid and there will always be so many calls, including long distance, toll and special, as well as local calls, which cannot be handled entirely by machinery, that very large numbers of operators will always be required and for a good many years to come the use of

the machine switching system means simply that the increase in the operating forces will be less than if the manual system were retained.

With the great growth of the business, it has become necessary to count the calls at the larger places in order to make the charges fair to all patrons, and for this purpose there are registering devices and special clocks for the operators' assistance. With the continual movement among subscribers, furthermore, means must be provided so that the operators will know, without stopping to refer to a list, if a subscriber has given up his telephone service, if he has moved to another office, or if for any reason his line is in trouble, and the operators must be constantly alert to note and report those conditions to the calling subscriber.

Complications in Metropolitan Areas

The preceding description has been concerned largely with a single office, and even one of these large offices is a tremendously complicated set of machinery requiring in some cases the services of as many as four hundred operators. Within thirty miles of New York, however, there is not one, but two hundred and sixty offices, many of which are as large as the present design of apparatus will permit. The calling subscriber, furthermore, expects to be connected promptly with any one of these two hundred and sixty offices, and the operators must know instantly the proper method of making connection to each office, and she must have facility in using the machinery provided for those connections. Direct trunk circuits are provided to offices to which there is a considerable amount of business. Offices to which there is less business are reached through other offices by tandem or double tandem methods, the essential circuit arrangement, operating methods and service being similar to that where there are direct trunks. In the case of a call which is double tandemed, however, four operators are required to complete a single connection.

Offices to which there are relatively few calls, usually those in the outlying sections, are reached by special operating methods through what are known as toll boards, and three of these connecting centers are required to reach all of the 260 offices. Beyond the metropolitan area, calls are handled through another form of toll or long distance board, of which more will be said a little later. When we consider that the subscriber simply announces the office name and number desired, it will be evident that the operator must be well trained and expert to know instantly through which one of many channels that office is reached and the proper operating method and equipment to employ in each case. The resulting complications of the switchboard itself are necessarily very great, with facilities for operating in hundreds of different directions. It is difficult to give a comprehensive picture of the intricate trunk plant connecting the different offices, but it may be of interest to state that in the city of New York as much underground cable plant is required to inter-connect about one hundred offices as is needed to connect 1,000,000 stations with their own offices. While the New York metropolitan area has the largest population and the most complicated telephone system, there are similar conditions in the case of all large cities, and the problems of the traffic department are constantly increasing with the growth in the business.

Toll and Long Distance Calls

Mention has been made of toll and long distance calls, which are those between two offices not in the same exchange area and for which a special charge is made in proportion to the distance. In no phase of telephone work have the developments been more startling than in extending the range of long distance calls. The first toll circuits were short and consisted of open wires connecting nearby cities. The operating methods were relatively simple and the operator answering the sub-

scriber could herself make connection over the few toll circuits then existing. Today, however, a subscriber can talk across the continent and even to islands beyond the continent, as in the case of Cuba—by means of submarine cables, and Catalina—by means of wireless working from the mainland. Whereas the first toll circuits consisted of a few miles of open wires, it would take several pages to even describe a telephone circuit connecting Boston, for example, with Catalina Island or Havana. In addition to thousands of miles of open wire, there are hundreds of miles of cable either underground or aerial, there are loading coils to overcome the capacity of the cables, there are repeaters to supply new energy to the conversation on its long journey, there are submarine cables or wireless links to cross the rivers and the sea, and there are innumerable equipment devices at the many offices through which the calls must route. The wires stretch across deserts and over mountains where they are frequently the only indication of civilization. When we consider that the slightest break in the 7,000 miles of wire or in any of the many pieces of apparatus would prevent a transcontinental conversation, it is a constant marvel that telephone plant can be built and maintained with the necessary degree of perfection. The work of operating a long distance call is also difficult and it is an enormous stride from the early days of short toll circuits over which two operators could complete a call to the present transcontinental connections, to handle each of which from ten to sixteen or more operators are necessary. A call, for example, from Augusta, Maine, to Catalina Island must be switched at Portland, New York, Chicago, San Francisco, Los Angeles and Long Beach, and the operating methods must be carefully worked out and the operators themselves must be expert in order that there may be perfect cooperation on such a call. That sort of call is a striking illustration of the necessity for uniform and standard operating methods and practices throughout the Bell System and a large force of men is continuously engaged

in the study of these methods and in the development of improved practices.

Magnitude of Traffic Work

The magnitude of traffic department operations can perhaps be visualized by the statement that the Bell owned companies alone employ 130,000 operators to serve some 9,000,000 stations, which make over 11,000,000,000 calls a year, and we are still far from the end. If we look forward to 1940, there will probably be 25,000,000 telephones in the United States, and the complexities of telephone plant and operations increase much more rapidly than the number of stations. The 130,000 operators are located in 5,800 offices, and it is a difficult problem to properly house and care for this large force. The telephone buildings and land alone represent an investment of over $150,000,000 and, as an interesting detail, in the single item of lunches, which are provided only in the larger cities where the girls cannot conveniently go home for lunch, there is a considerable business turning over some $8,000,000 a year.

In spite of the great growth in the business and the enormous increase in its complications, American telephone service today is the best that it has ever been, and the telephone operators and the traffic supervising forces may well be gratified at the record they have made and are making in public service. It is no time, however, to rest on past accomplishments, since the traffic problems of the future will be more difficult than those of the past. If the traffic departments continue to work with the same zeal and intelligence, there is every reason to believe that they will be equal to the demands upon them, and I hope that this short article will give some picture of their problems and of the work of telephone operating, which has become one of the principal and best considered occupations for women.

K. W. Waterson.

Poles

NEXT to the telephone instrument itself, the element of telephone plant which is most familiar to the public is the pole. In attempting to visualize the enormous number of poles required by the Bell System, it may be helpful to consider that the nearly 15,000,000 poles now in use would furnish sufficient material for a railroad trestle, thirty feet high, reaching from Chicago to Buenos Aires. Additions and replacements call for three-quarters of a million new poles each year, or enough to build a telephone line two-thirds of the distance around the earth. These comparisons may also serve to indicate the magnitude and the consequent importance of the pole problem in the Bell System.

Much work has been done by Bell System engineers to enable pole lines to be designed so as to meet service conditions most economically. This has included investigations of the stresses in the poles and other portions of the line under such wind and ice loads as may reasonably be expected to occur in the locality where the line is constructed, experiments to determine the strengths of many different kinds of timber and researches into the effects of various preservatives in increasing the durability of poles.

The most economical poles for use in any particular section of the country are those poles which will withstand the required load at the minimum annual cost.

The load carried by a pole depends upon the weight of the wires or cables which it sustains and the pressure of the wind upon them. The most severe loads occur when the wires or cables are heavily coated with ice and a strong wind is blowing in a direction at right angles to the line.

Factors which affect the load, in addition to the number and size of wires and cables, are the lengths of spans between poles, the climatic conditions (wind and ice) to

which the line is exposed, and the degree of shelter of the line, as by hills, forests or buildings.

The annual cost, which includes return on investment, taxes, reserve for replacement and maintenance, depends chiefly on first cost and length of life.

Into the first cost of the pole, in place, enter such items as the price at the woods, the freight rate (depending on the weight of the pole and the distance of the place where it is to be used from the point of supply), and the cost of hauling and erecting.

The length of life depends upon a variety of factors, the most important of which (apart from questions of inadequacy and obsolescence) are the character of the timber, whether or not a preservative treatment is employed and, if so, the nature of the treatment, the local climatic conditions and the original size of the pole.

The importance of the latter factor, the original size of the pole, is due to the fact that those who are responsible for the plant and the service have to decide, for every type of construction, taking into account all the conditions of location, exposure and use, how little sound wood may remain at the ground line section of the pole before it should be replaced on account of decay. If the original size of the pole is only slightly more than this critical size at which replacement should be made, the life of the pole will be very short as decay will reduce the size at the ground line to the critical size within a few years.

On the other hand, whereas a pole of huge size at the ground line would have a very long life before decaying sufficiently to require replacement, the cost of so stout a pole might readily be so great that its annual cost would exceed that of a smaller and cheaper pole.

Principal Kinds of Pole Timber

The principal kinds of wood used for poles are eastern cedar, western cedar, chestnut, and yellow pine. The eastern cedar now used for poles comes mainly from

Minnesota. There are also extensive tracts in Canada, and some in northern Maine. In years past enormous quantities have been cut in both the northern and southern peninsulas of Michigan, and in northern Wisconsin. Locations in swamps and along streams afford favorable conditions for the growth of this timber. Under normal conditions cedar poles require from one hundred to two hundred years to grow. Western cedar grows on both the eastern and western slopes of the Cascade Mountains and on the western slope of the Rocky Mountains in the extreme northwest section of the United States and adjoining parts of Canada. Chestnut is found principally along the Atlantic Coast and in the Appalachian Mountain regions. North of Virginia, chestnut has within recent years been practically exterminated by the chestnut blight. While the blight-killed trees have been available for poles, this region, after being cut over, will, in general, cease to be a source of future supply, at least for many years. To what extent the blight will enter the region south of Virginia, where are found the principal stands of chestnut timber, cannot be answered at the present time. Chestnut grows more rapidly than cedar, an average chestnut pole requiring from forty to sixty years to grow. Yellow pine grows principally in the south Atlantic and gulf states. Pine grows quickly, on the average taking somewhat less time than chestnut to produce poles.

Strength and Weight

Chestnut, yellow pine, and western cedar are about equal in strength. Eastern cedar has about 70 per cent. of the strength of these timbers. The values as to timber strength which form the basis for pole line design in the Bell System have been derived by our engineers from experiments on poles which have been tested by breaking them under measured loads. The figures are considerably smaller than those frequently found in text books on strengths of materials. The difference

is due to the defects found in the actual poles, whereas the small specimens subjected to the ordinary laboratory tests are so selected as to be clear and straight-grained. Tests recently conducted on some old cedar poles that had been many years in service show that there is but little, if any, tendency for the fibre strength to deteriorate when the wood remains sound.

There is considerable difference in the weights of the different pole timbers. This has a direct bearing on the costs of transportation and distribution and, to some extent, affects the cost of erecting. Chestnut and creosoted yellow pine poles weigh almost twice as much as cedar poles of the same size. In the case of yellow pine the treating process adds about a third to the weight of the untreated pole. The degree of seasoning has a considerable effect on the weights of poles. Chestnut poles are ordinarily shipped in a fairly green condition, whereas cedar poles are frequently held at a concentration point for a sufficient time to season partially, at least. Except in the case of unusually tall poles, the weakest section is at or close to the ground line. For poles of a given length and kind of timber, the breaking strength varies theoretically with the cube of the diameter at the weakest section. This relation serves to show why it is that thick poles are so much stronger than slim poles. For example, a pole 12 inches in diameter at the ground line is 70 per cent. stronger than one 10 inches in diameter, and a 15-inch pole is 240 per cent. stronger than a 10-inch pole. This relation also explains why it is that a limited amount of "hollow heart" has only a trifling effect on the strength of a pole.

Only those kinds of timber which are most durable after the trees are cut are suitable for poles. Hardness and density of the wood seem to have no effect on its durability. The durability of short-lived timber can, however, be increased greatly by suitable preservative treatment. This is necessary in the case of yellow pine, and is advantageous in many cases with other kinds of timber. The action of the preservative in retarding

decay can perhaps be more readily understood after a brief explanation of the nature of decay in timber.

Nature of Decay

Wood is composed of a multitude of minute elongated cells which lie closely side by side to form the wood structure. The surfaces of these cells are in contact with each other and are held together firmly by a cement-like tissue. When timber is fractured there is a tearing away of these cemented surfaces. The decay of timber is caused by the activity of low forms of plant life, principally in the form of fungus threads, which feed upon and dissolve the walls of these wood cells. These organisms are so minute that a powerful microscope is required to see them, yet their work results in the destruction of billions of feet of timber every year. They can grow either in light or darkness, but all of them require certain amounts of air, moisture, heat, and food; the latter being the wood itself. If one or more of these things is lacking the organism cannot live and the decay of timber will not take place. Wood constantly submerged in water does not rot, because there is an insufficient supply of air. On the other hand, if wood can be kept dry it will not decay, because there will then be too little moisture.

The decay-producing fungi do not flourish in ordinary soils at a depth of more than about two feet, on account of the lack of air. The atmospheric moisture is sufficient to permit the development of the dry-rot fungus. Wood freshly cut contains enough water at all seasons of the year to enable the decay organisms to flourish. In the case of cedar and chestnut poles, the portion of the pole above ground does not ordinarily decay, except at a very slow rate. The butt end of the pole, deeply buried in the ground, although frequently permanently damp, does not get sufficient air for rapid decay to take place. It is near the ground line, where the earth holds the moisture and keeps the wood damp for long periods in the presence of air, that decay is most rapid. Pre-

servatives act antiseptically to kill the fungus growths that produce decay. They are also effective to some extent in preventing the entrance of moisture by plugging the pores of the wood.

Preservatives

Various metallic salts, such as zinc chloride, copper sulphate, and corrosive sublimate, have been used in this country and in Europe for preserving timber for various uses, but experience has shown that dead oil of coal tar, usually termed coal tar creosote, or simply creosote, is more effective for pole preservation than these metallic salts. While the preservative action is probably due to the poisonous effects of water soluble constituents of the preservative, it is also important that the preservative as a whole should not be freely soluble in water as then it would be leached from the timber too quickly. It is also obvious that the use of materials poisonous to human beings and domestic animals is undesirable.

Bell System engineers early appreciated the advantages of creosote as a preservative, and for fully twenty-five years they have been acquiring data as to the results obtained from its use. This has been done by placing large numbers of experimentally treated poles alternately with untreated poles in lines in various parts of the country and, at regular intervals, usually every three years, carefully measuring the extent of decay in both the treated and untreated poles. Examinations thus made of thousands of poles treated in various ways have enabled trustworthy and reliable results to be obtained from which to determine the added life resulting from the treatment.

While our experiments have largely been directed toward discovering the best methods of using coal tar creosote, we have by no means neglected to test many other kinds of preservatives. In fact, our experiments have included every known preservative which has offered promise of success. At the present time numerous

preservative materials and processes are undergoing preliminary trial in a special laboratory room maintained at a temperature and humidity favorable to decay, where test specimens of timber, to which the new materials and methods have been applied, are placed in close proximity to the decay-producing fungi. By this means results are obtained in a few years which are fairly comparable to those which would require considerably longer under actual service conditions.

Yellow pine, although a strong and otherwise satisfactory pole timber, decays rapidly, particularly in the South, if used without preservative. Moreover, the decay is not confined to the ground line, but speedily affects the entire pole in the absence of suitable treatment. Fortunately, the structural character of this timber is such that it can readily be treated. All yellow pine poles used in the Bell System are creosoted throughout their entire length. The usual method of applying this treatment requires a somewhat elaborate plant, the principal feature being the treating cylinder, of which there are several at each of the larger plants. The average modern treating cylinder ranges from 120 to 130 feet in length and from 6 to 7 feet in diameter. It is constructed like a steel boiler shell, with one or both ends hinged so that they can be opened. The timber to be treated is piled on small cars which run on rails that lead directly into the cylinder at one end. After the timber is moved into the cylinder the latter is tightly sealed and filled with steam. The timber is steamed for several hours, the length of time and the temperature being regulated by the specifications which our engineers have prepared in the light of all their experience with these matters. The steaming softens and opens the wood cells and liquifies and removes the resinous and sappy constituents of the timber. After the steaming is discontinued a vacuum is applied to the cylinder. This assists in evaporating the water left in the timber after the steaming process. When the vacuum has done its work, the pumping is stopped and the cylinder filled

from a large tank containing hot creosote. After the cylinder is completely filled, pressure sufficient to force the specified amount of oil into the timber is applied. After the pressure is released the oil is pumped back into the tank and the difference in the initial and final readings of the gauge attached to the tank shows the amount of oil that has been absorbed by the timber.

In the case of cedar and chestnut the portion of the pole above the ground line has normally a very long life. It is the portion of the pole at or just below the ground line which decays most rapidly. For this reason much attention has been given to methods for applying preservatives to the butt end of the pole, extending up for about a foot above the ground line, and leaving the upper portion of the pole untreated. The simplest way of doing this is to apply the preservative like paint with a brush. In order that definite information might be obtained as to the value of these brush treatments, the American Telephone and Telegraph Company, in 1902, initiated a series of experiments jointly with the United States Forest Service. Several hundred poles were included in these tests. All the preservatives used were carefully analyzed. The experiments included brush treatments with several different kinds of carbolineum, dead oil of coal tar, and a number of kinds of wood creosote. Some of these poles were set in the coast region of Georgia, where conditions are favorable to rapid decay, and some were set in western Pennsylvania and New York. The treated poles were set alternately with untreated poles, in order that comparisons might be made.

Another line of experimentation which has been carried out by this company in cooperation with the Forest Service has been the treatment of pole butts with creosote by the so-called "open tank" process. With this method the butts of the poles are placed in a tank and immersed in creosote to a point about one foot above the ground line. The creosote is then heated above the boiling point of water, generally by means of steam pipes within the tank. This converts the water in the wood

cells into steam, most of which escapes by bubbling through the oil. The air in the wood cells is also expanded and partially expelled. After the pole has been thoroughly heated in this manner, the hot creosote is quickly replaced by cool creosote, or the poles are quickly transferred to another tank containing cold oil. In either case the effect is to form a partial vacuum in the wood cells, allowing the creosote to be forced into the timber by atmospheric pressure. These poles have been inspected regularly and a large amount of information obtained as to the extension of their life resulting from the treatment.

Improvements in treating have recently been made whereby, by perforating the sapwood of the pole for a short distance above and below the ground line, it is made easier for the creosote to enter the wood at this section of the pole, and more uniform depths of penetration are secured. The perforations are generally from a quarter to a half inch deep, and are closely spaced.

Untreated chestnut rots considerably faster than untreated cedar. For this reason, coupled with the expectation of future scarcity of chestnut, work is being actively pushed which is expected to lead to the installation of local treating plants, within the areas from which the supply of chestnut poles is now being drawn, so that the poles may be concentrated at these points and given an effective treatment, extending from the butt to a point above the ground line when the pole is set. The first of these plants, with a capacity of 10,000 poles a year, is scheduled for completion by the end of this year.

Creosote contains various volatile and soluble constituents, which very gradually escape from treated timber during protracted exposure to the elements. Creosoted poles that have been in service from 10 to 25 years have been removed from the line and the creosote extracted from them and analyzed with great care. As the original composition of the creosote had been very carefully determined by analysis at the time when the poles were treated, it has been possible to discover what

changes had taken place in it. Investigations of this kind are still going on. They are important in that they furnish data that enables our engineers to revise the specifications for the creosote in order to obtain the grade that is best suited to the work. They are showing that most of the constituents of the creosote tend slowly to escape from the treated timber, the action being more rapid in the portions of the poles which are above ground. The rate of escape, however, is so slow that the value of the treatment is well established.

Poles of Steel and Concrete

The question is sometimes asked why poles of steel or of reinforced concrete are not more generally used instead of wood poles. Our engineers in 1909, designed a series of concrete poles of which a large number were constructed. Some of these were tested and their actual breaking load was found to be close to the computed values. The remainder of these poles, about 500 in all, were placed in actual service in pole lines in various parts of the United States, in order that their behavior under the stresses due to wind and sleet loads, the vibration caused by the wires and cables, and the effects of frost, lightning, and other actions of the elements might be observed. The poles are being inspected every three years.

The most expensive element in a reinforced concrete pole is the steel reinforcement. Steel is vastly more expensive per cubic foot than either concrete or wood. In order to obtain reinforced concrete poles comparable in strength with the wooden poles generally used in the telephone plant, so much steel is required that poles of reinforced concrete or steel are much more expensive than wooden poles, even at the prices which obtain at the present time.

Looking into the Future

These concrete poles have not been made with the thought that they or any other concrete poles will gen-

erally supersede wooden poles within a short time. They have been placed in service so that experience with them will be obtained which will serve as a guide to our engineers in the future, should the time ever come when the relative costs of these poles in comparison with wood are such as to indicate that their use might be justifiable.

It is the aim of our engineers in the conduct of this, as well as all of our experimental work, to anticipate future conditions and such new requirements as may be brought about thereby, sufficiently in advance so that we shall be able to develop and have ready thoroughly tried-out materials and methods when these are required, to the end that the orderly expansion of the business will not be checked and the Associated Companies forced to install new and untried materials in their plants. This work is one portion of the Bell System policy of preparedness.

FREDERICK L. RHODES.

World's Telephone Statistics

ON January 1, 1921 there were 20,850,550 telephones in the world; of these 13,329,379, or 64%, were in the United States and 12,601,935, or 60%, were connected to the Bell System. The number of telephones in all the countries of Europe combined was 5,289,606, or 25% of the world's total; all other countries had 2,231,565 telephones, or only 11% of the world's total. During the seven years 1914 to 1920, inclusive, 5,962,000 telephones were added to the telephone systems of the world, an increase of 40%. The total number of telephones at the beginning of 1921 was equivalent to 1.2 instruments for each 100 of the world's population.

The Scope Of The Statistics

These figures summarize the results of a compilation of the world's telephone statistics for January 1, 1921 recently completed and published by the Chief Statistician's Division of the American Telephone and Telegraph Company, from which the accompanying tables and charts have been taken. Owing to the war, which interrupted our lines of communication with many foreign countries on statistical matters, this compilation constitutes the first complete summary of its kind which has been made since that for January 1, 1914. Upon the termination of the war, communication was gradually reestablished with officials of foreign telephone systems, both Government and private; and it is upon data obtained through the courteous cooperation of such officials that the present compilation is based. It should perhaps be pointed out that the preparation of such a compilation, depending as it does upon the relatively slow processes of correspondence with various types of organizations in all quarters of the globe, necessarily requires the expenditure of considerable time if complete results are to be secured.

Despite the disturbed conditions which have prevailed in many parts of the world, accurate official information

TELEPHONE DEVELOPMENT OF THE WORLD, BY COUNTRIES, JANUARY 1, 1921

	Number of Telephones			Per Cent of Total World	Telephones per 100 Population	Per Cent Increase in Telephones since Jan. 1, 1914†
	Government Systems	Private Companies	Total			
NORTH AMERICA:						
United States	.....	13,329,379	13,329,379	63.92%	12.4	39.7%
Canada	181,930	674,336	856,266	4.11%	9.8	71.4%
Central America	6,337	9,613	15,950	.08%	0.3	102.4%
Mexico	1,860	42,924	44,784	.21%	0.3	7.0%
West Indies:						
Cuba	464	33,912	34,376	.16%	1.1	113.5%
Porto Rico	555	7,415	7,970	.04%	0.6	81.5%
Other W. I. Places*	2,958	7,180	10,138	.05%	0.2	53.5%
Other No. Am. Places*	40	3,160	3,200	.02%	0.8	37.0%
Total	194,144	14,107,919	14,302,063	68.59%	9.8	41.3%
EUROPE:						
Austria	133,480	.....	133,480	.64%	2.2	-22.5%
Belgium	62,867	.....	62,867	.30%	0.8	-3.3%
Bulgaria*	5,000	.....	5,000	.02%	0.1	38.6%
Czecho-Slovakia	77,195	.....	77,195	.37%	0.6	XX
Denmark (March 31, 1921)	7,230	245,091	252,321	1.21%	7.7	95.4%
Finland*	.....	45,000	45,000	.22%	1.3	12.5%
France	473,212	.....	473,212	2.27%	1.2	43.3%
Germany	1,809,574	.....	1,809,574	8.68%	3.0	27.4%
Great Britain	985,964	.....	985,964	4.73%	2.1	26.3%
Greece	4,700	.....	4,700	.02%	0.1	46.9%
Hungary	57,009	.....	57,009	.27%	0.7	-32.1%
Italy (June 30, 1920)	79,934	35,043	114,977	.55%	0.3	25.2%
Jugo-Slavia	16,439	.....	16,439	.08%	0.1	XX
Netherlands	160,733	1,200*	161,933	.78%	2.4	87.3%
Norway* (June 30, 1920)	73,372	62,000	135,372	.65%	5.0	64.0%
Poland*	47,450	25,000	72,450	.35%	0.3	XX
Portugal*	1,800	13,621	15,421	.07%	0.2	74.2%
Roumania (March 31, 1921)	24,701	.....	24,701	.12%	0.1	23.5%
Russia*	200,000	.....	200,000	.96%	0.2	XX
Spain*	5,000	65,000	70,000	.34%	0.3	105.9%
Sweden	386,341	1,789	388,130	1.86%	6.6	66.6%
Switzerland	152,336	.....	152,336	.73%	3.8	57.7%
Other Places in Europe*	30,365	1,160	31,525	.15%	0.2	XX
Total	4,794,702	494,904	5,289,606	25.37%	1.2	31.9%

* Partly estimated.
† No allowance has been made in these figures for any change in territory since January 1, 1914. Minus sign preceding a figure denotes decrease.

* Partly estimated.
†No allowance has been made in these figures for any change in territory since January 1, 1914. Minus sign preceding a figure denotes decrease.

	Number of Telephones			Per Cent of Total World	Telephones per 100 Population	Per Cent Increase in Telephones since Jan. 1, 1914†
	Government Systems	Private Companies	Total			
SOUTH AMERICA:						
Argentine	.....	116,553	116,553	.56%	1.3	56.8%
Bolivia (Jan. 1, 1920)	.....	2,517	2,517	.01%	0.1	0.7%
Brazil	1,247	83,844	85,091	.41%	0.3	117.2%
Chile	.....	29,867	29,867	.14%	0.8	51.6%
Colombia	.....	6,843	6,843	.03%	0.1	115.3%
Ecuador	1,425	2,521	3,946	.02%	0.2	34.9%
Paraguay	138	268	406	.01%	0.04	-18.6%
Peru	2	8,550	8,552	.04%	0.2	113.6%
Uruguay	.....	22,381	22,381	.11%	1.5	64.7%
Venezuela	663	8,233	8,896	.04%	0.3	76.9%
Other Places (Jan. 1, 1920)	1,898	.....	1,898	.01%	0.4	34.3%
Total	5,373	281,577	286,950	1.38%	0.4	72.4%
ASIA:						
British India	13,000*	21,268	34,268	.16%	0.01	93.6%
China*	52,500	21,960	74,460	.36%	0.02	XX
Japan	330,597	.....	330,597	1.59%	0.6	50.7%
Other Places in Asia*	49,473	4,847	54,320	.26%	0.04	115.1%
Total	445,570	48,075	493,645	2.37%	0.1	61.3%
AFRICA:						
Egypt (March 31, 1920)	22,280	.....	22,280	.11%	0.2	29.1%
Union of South Africa	51,402	.....	51,402	.24%	0.7	77.8%
Other Places in Africa*	27,076	1,448	28,524	.14%	0.02	50.5%
Total	100,758	1,448	102,206	.49%	0.1	57.0%
OCEANIA:						
Australia (June 30, 1920)	224,000	.....	224,000	1.08%	4.3	62.8%
Dutch East Indies	33,225	1,279	34,504	.16%	0.1	132.5%
Hawaii	.....	14,376	14,376	.07%	5.6	97.4%
New Zealand (March 31, 1921)	88,439	.....	88,439	.42%	7.0	79.0%
Philippine Islands	1,955	10,496	12,451	.06%	0.1	84.3%
Other Places in Oceania*	2,073	237	2,310	.01%	0.1	44.7%
Total	349,692	26,388	376,080	1.80%	0.6	73.0%
TOTAL WORLD	5,890,239	14,960,311	20,850,550	100.00%	1.2	40.0%

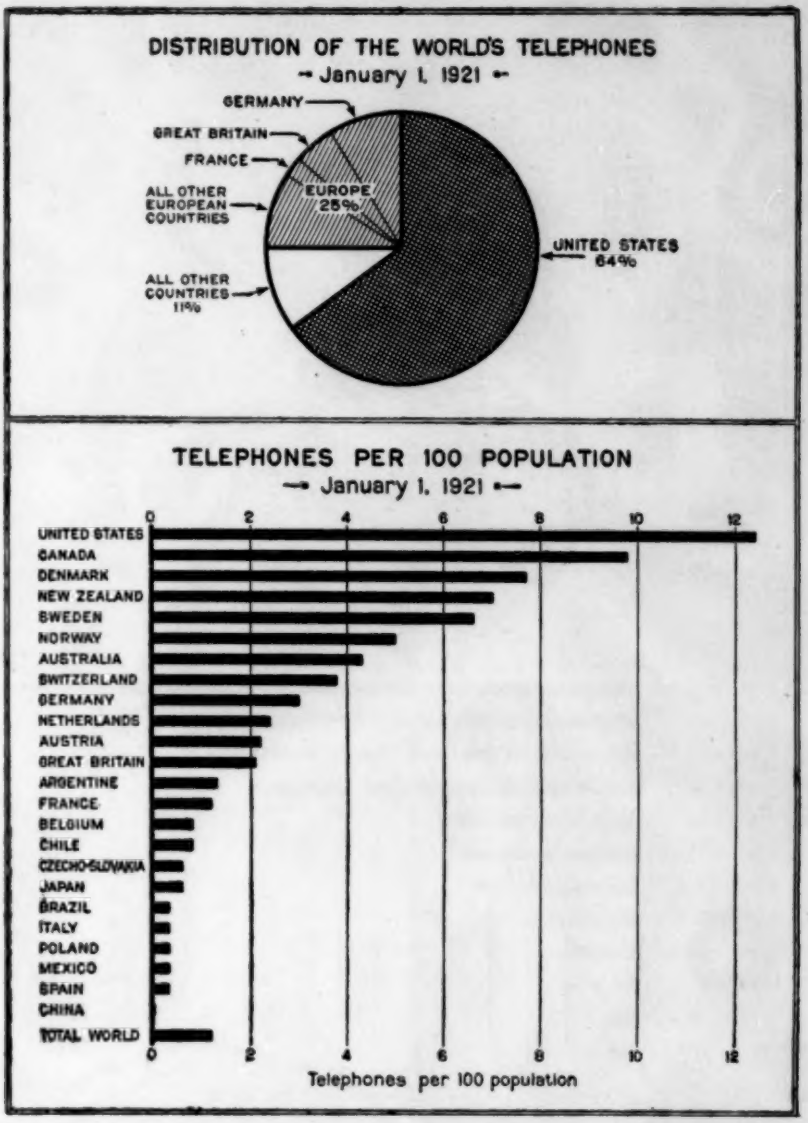
* Partly estimated.
†No allowance has been made in these figures for any change in territory since January 1, 1914. Minus sign preceding a figure denotes decrease.

was received for almost all countries, including the new European states created as a result of the peace treaties. In the case of those countries for which it was impossible to secure wholly authoritative figures for January 1, 1921, estimates were, of course, necessary; but practically without exception it was possible to base these estimates upon official data for earlier years, and accordingly the margin of error to which they are subject is undoubtedly very small. In the table on "Telephone Development of the World, By Countries", it was not considered practicable to show data separately for each individual country; for purposes of condensation the less important countries and political divisions in each of the major continental divisions have been grouped under the designation "Other Places". In the case of Europe, "Other Places" include Albania, Armenia, Azerbaijan, Azores, Canary Islands, Dantzig, Esthonia, Faroe Islands, Fiume, Georgia, Gibraltar, Iceland, Latvia, Lithuania, Luxemburg, Madeira, Malta, Monaco, and Turkey; and the fact that official data were secured for nearly all of these places in which there were any telephones at all is an indication of the completeness of the figures. In the preparation of the compilation, statistics on telephone revenues and investment were secured; but as a result of the inflated condition of many foreign currencies, these statistics have little comparative significance and consequently have not been published.

Comparative Telephone Development of Countries

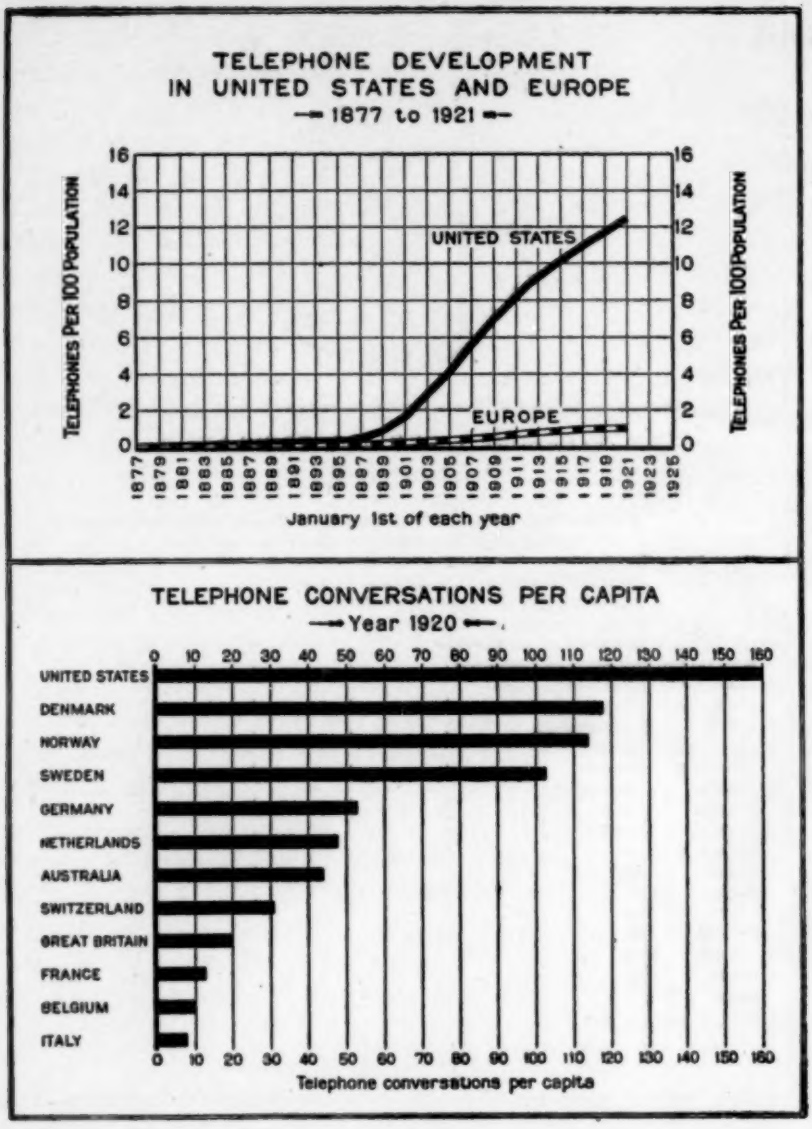
In point of the extent of telephone service relative to population, the table on "Telephone Development of the World, By Countries" shows that the United States, with 12.4 telephones per 100 population on January 1, 1921, still leads all other countries by a substantial margin. Moreover, it is significant that the countries next in rank in telephone development—Canada with 9.8 telephones per 100 population and Denmark with

7.7—are countries in which private operation of telephone service predominates.



Europe as a whole has only 1.2 telephones per 100 population, a stage of development reached in the United

States as early as 1900. Among the individual European states, the highest number of telephones per 100 popula-



tion is found in the Scandinavian countries—Denmark (7.7), Sweden (6.6) and Norway (5.0)—in all of which

the service has been developed largely by private initiative, although in Sweden the Government has now acquired most of the private systems. Despite the fact that Germany has only 3.0 telephones per 100 population, it ranks ahead of Great Britain with 2.1 and France with 1.2. Italy has only 0.3 telephones for each 100 of its inhabitants, a figure which is equalled by Poland and exceeded by Czecho-Slovakia.

In South America, the best developed country from a telephone standpoint is Uruguay, which can boast of 1.5 telephones per 100 population, whereas Argentine shows only 1.3. As is to be expected, Japan leads the Asiatic states in telephone development; but with all its progressiveness, Japan still has only 0.6 telephones per 100 inhabitants. Africa is as barren telephonically as is Asia. In Oceania, Australia (4.3) and New Zealand (7.0) rank high as against those comparable European countries in which telephone service has been controlled by Governmental agencies, but their development is low when compared with United States standards.

Changes Since 1914

The last column in the table on "Telephone Development of the World, By Countries" shows the percentage increase since January 1, 1914 in the number of telephones in each country. These percentage increases should, of course, be interpreted in the light of the absolute number of telephones at the beginning of the period, since those countries which had relatively few telephones on January 1, 1914 naturally tend to show the largest increases in terms of percentages. With this qualification, however, the figures afford a good indication of the progress that has taken place in the telephone world during the years 1914-1920, inclusive.

In the United States, the number of telephones increased by 40%, as compared with an increase of 32% in Europe. In absolute numbers, the increase in the United States was about 3,800,000 telephones,—a figure

almost equal to the total number of telephones in use in all Europe on January 1, 1914. Among the European countries, telephone growth has been diversely affected by war influences and by changes in territorial boundaries. In Austria and Hungary loss of territory substantially reduced the total number of telephones, though telephones per 100 population have increased in both countries because the lost territory was, as a whole, the least developed. Of the new states created as a result of the war, the largest number of telephones (77,195) is in Czecho-Slovakia, though Poland with 72,450 telephones is not far behind. In the neutral countries telephone growth has naturally been more rapid than in the belligerent nations; indeed, in most of the former countries the war gave an exceptional stimulus to the extension of the service. Thus, in Denmark the number of telephones almost doubled during the seven years covered by the table, while the increases in The Netherlands, Norway, Sweden, Spain and Switzerland were also relatively large. In Belgium, German invasion and occupation seriously crippled the service; but the recovery after the war was rapid and on January 1, 1921 there were almost as many telephones in use in Belgium as in 1914. In France, Great Britain and Italy telephone growth was practically halted during the war, but substantial increases were recorded in the years 1919 and 1920; in the case of France, the increase was augmented by the acquisition of Alsace-Lorraine and the purchase of the telephone system of the American Expeditionary Forces. In Germany the number of telephones apparently increased slightly throughout most, if not all, of the war period; and despite its territorial losses the absolute gain in telephones during the seven years 1914-1920 was greater in Germany than in any other European country.

In South America, Asia, Africa and Oceania a steady extension of telephone service is indicated in almost every country.

TELEPHONE DEVELOPMENT OF IMPORTANT CITIES, JANUARY 1, 1921

Country and City (or Exchange Area)	Estimated Population (City or Exchange Area)	Number of Telephones	Telephones per 100 Population
AUSTRALIA:*			
Melbourne	767,000	48,461	6.3
Sydney	899,000	58,594	6.5
AUSTRIA:			
Vienna	1,842,000	98,000	5.3
BELGIUM:			
Antwerp	502,000	10,028	2.0
Brussels	885,000	23,809	2.7
DENMARK:			
Copenhagen	666,000	96,008	14.4
FRANCE:			
Lyons	562,000	10,986	2.0
Marseilles	586,000	11,859	2.0
Paris	2,906,000	159,692	5.5
GERMANY:			
Berlin	2,170,000	199,555	9.2
Cologne	634,000	35,514	5.6
Dresden	529,000	33,150	6.3
Hamburg-Altona	1,155,000	85,748	7.4
Leipzig	604,000	38,830	6.4
Munich	631,000	42,174	6.7
GREAT BRITAIN:*			
Birmingham	1,273,000	26,477	2.1
Dublin	387,000	11,213	2.9
Edinburgh	420,000	16,561	3.9
Glasgow	1,260,000	43,263	3.4
Leeds	536,000	12,999	2.4
Liverpool	1,190,000	38,475	3.2
London	7,069,000	330,002	4.7
Manchester	1,591,000	46,313	2.9
HUNGARY:			
Budapest	926,000	24,205	2.6
ITALY:			
Milan	718,000	15,000‡	2.1
Naples	780,000	6,800‡	0.9
Rome	689,000	13,000‡	1.9
Turin	517,000	7,500‡	1.5
JAPAN:			
Osaka	1,253,000	33,004	2.6
Tokio	2,173,000	64,564	3.0
NETHERLANDS			
Amsterdam	642,000	31,392	4.9
The Hague	353,000	22,393	6.3
Rotterdam	510,000	24,848	4.9
NEW ZEALAND:*			
Auckland	158,000	9,791	6.2
Wellington:	107,000	10,375	9.7
NORWAY:†			
Christiania	256,000	29,802	11.6
Bergen	97,000	6,970	7.2
PORTUGAL:			
Lisbon	820,000	9,939	1.2
SWEDEN:			
Göteborg	202,000	23,778	11.8
Stockholm	376,000	118,180°	31.4°
SWITZERLAND:			
Berne	112,000	10,016	8.9
Geneva	136,000	13,714	10.1
Zurich	211,000	20,023	9.5
UNITED STATES:			
New York	5,708,000	892,198	15.6
Chicago	2,755,000	575,840	20.9
Total of the 30 cities in U. S. with over 250,000 population	25,176,000	4,201,614	16.7

* Statistics as of March 31, 1921. † Statistics as of June 30, 1920. ‡ Number of subscribers.
° The greater part of this development was secured by a private company which was purchased by the Government in 1918. On January 1, 1921 the process of merging the company's plant with the Government's local system was not fully completed and the total number of telephones still included a certain number of duplicates.

Comparative Telephone Development Of Cities

Referring to the table on "Telephone Development of Important Cities", the superiority of telephone development in the United States is again clear. With the exception of a few cities in the Scandinavian countries and one city in Switzerland, none of the foreign cities has a development as high as 10 telephones per 100 population, while the 30 United States cities with over 250,000 population show an average development of 16.7 telephones per 100 inhabitants. Indeed, several American cities have as many telephones as there are in the whole of such important European countries as France or Italy. From an American standpoint, even such metropolitan centers as London and Paris are woefully under-developed. In the case of Stockholm, for which a development of 31.4 telephones per 100 population is reported, the number of telephones includes a certain number of duplicates and the development is consequently overstated. Due to the energetic initiative of the Stockholm Telephone Company, which operated the greater part of local service in Stockholm up to 1918, it is true that this city has attained a far higher telephone development than any other foreign city; but it is probable that if proper allowance were made for duplicate telephones, Stockholm would be found to rank below the highest developed cities in the United States.

In comparing the development of the cities shown in this table with the development of the corresponding countries as shown in the first table, a marked disparity between the development of the cities and that of the countries in which they are located will be noted in the case of most of the foreign countries. This disparity reflects the fact that in foreign countries telephone service is confined principally to the cities. One-third of all the telephones in France are in Paris; London also has one-third of all the telephones in Great Britain. Except in the United States and Canada, rural telephone service is almost unknown.

S. L. Andrew.

Abstracts of Recent Technical Papers from Bell System Sources

Measurement of direct Capacities,[1] by Dr. G. A. Campbell. In distinction to "mutual capacity" and "grounded capacity" the concept and measurement of "direct capacity" is very useful to the telephone engineer, enabling him to control cross-talk and to determine more completely how telephone circuits behave under all possible connections. The article describes typical methods for measuring direct capacity, direct admittance and direct impedance and indicates that the substitution alternating current bridge method, devised some years ago by Mr. E. H. Colpitts, Assistant Chief Engineer of the Western Electric Company, is a very satisfactory method.

Education and the Art of Electrical Communication,[2] by E. B. Craft. On July 21, Mr. E. B. Craft, Chief Engineer of the Western Electric Company, delivered an address on the above subject from his office, to a large gathering of teachers, assembled in the Lincoln School of Teachers' College, New York City. The address was carried over a telephone circuit and projected by the Bell loud-speaker in the manner which has now become so familiar. Mr. Craft pointed out that while the problems of the teachers are steadily becoming more complex, it may be possible to adapt many of the developments of present day science, including some of those which the telephone engineers have originated, to aid in the solution of teaching problems.

The speaker emphasized the great importance, to those who are preparing for technical positions in the industries, of broad fundamental training as well as a super-structure of specialized training. To quote "There is no part of education, from the primary school to the highest training of the graduate school, in which we [the

[1]See Bell System Technical Journal—July 1922—Page 18, and Journal of the Optical Society of America and Review of Scientific Instruments—Aug., 1922.

[2]Issued in pamphlet form by the Western Electric Company.

Bell Telephone System] do not have a vital interest and do not feel the effect of every improvement in educational methods."

Mr. Craft also outlined briefly the training courses which the Western Electric Company has established for those of its employees who must, for one reason or another, close their academic training upon graduation from high school. This course runs for three successive years, and in character and difficulty is entirely comparable to the courses offered by high-grade technical schools.

The Frequency-Sensitivity of normal ears,[1] by H. Fletcher and R. L. Wegel. A large amount of work has been done during the last fifty years in an endeavor to determine the minimum amount of sound that the human ear can perceive, but the results of different investigators have varied throughout a wide range. It is important for the proper engineering of the telephone plant to know the sensitiveness of the ears of the average telephone user. For this reason, the present investigation was undertaken. Apparatus is described for producing pure tones, ranging in frequency from 60 cycles to 6000 cycles, and in intensity from tones so faint as to be inaudible, to tones which are so loud as to be painful to the ear. Frequency-sensitivity curves have thus far been obtained for approximately 100 normal and 20 abnormal ears. On the average, the minimum audible pressure variation decreases regularly from about 0.15 dyne/cm^2 at 60 cycles, to 0.001 dyne/cm^2 at 1000 cycles, and is then approximately constant up to at least 4000 cycles. Persons who require throughout the speech range (600 to 4000 cycles) about 0.1 dynes/cm^2 are called slightly deaf; those requiring 1 dyne/cm^2 can still follow ordinary conversation; those requiring 10 dynes/cm^2 belong to the class who may be benefitted by ear trumpets or amplifiers. A pressure variation of approximately 1000 dynes/cm^2 can be felt and produces a sensation of pain.

[1]Physical Review—Vol. 19, p. 553, June, 1922.

Static interference as a function of wave length,[1] by H. T. Friis and L. J. Sivian. The purpose of this note is to comment upon a recent theoretical investigation by M. Abraham of the relative immunity from atmospheric disturbances in closed loop and open aerial forms of receiving antennas, and upon a subsequent paper by L. B. Turner on the ratio between signal intensity and static intensity as a function of signal wave length. The calculations in the latter paper are based on Abraham's results which are believed to be an error by the present authors. They arrive at results which indicate that for any given range of signaling the optimum wave length is the same for both loop and open antennas.

The Fire-fly as an illuminant,[2] by Herbert E. Ives. The purpose of this paper is to review the results of a series of studies made some years ago on the physical properties of the light emitted by the fire-fly. Much interest has been bestowed upon the fire-fly's light because it appears to be produced very efficiently and its secret, when understood, may have great practical value. The most important practical questions to be answered in studying an illuminant are three: *How much* light does it produce; how *efficiently* does it produce the light; what is the *quality* of the light?

These questions the author considers in turn. He finds that although the amount of light which the fire-fly emits per unit area of its body is very small compared to a flame or heated filament, it is sufficiently intense to be entirely practicable for many illuminating purposes. The efficiency of the fire-fly's light can only be roughly estimated but appears to be ten or even twenty times that of the best artificial illuminants. Spectrum analysis of the light from the species *Photinus Pyralis* revealed the fact that practically all the rays lie in a narrow region of the spectrum between the orange and green. The light, although it lies in that part of the spectrum for which the human eye is most sensitive and

[1] Wireless World and Radio Review—June 3, 1922.

[2] Journal of the Franklin Institute, Vol. 194, p. 213, August, 1922.

would be very useful for making fine detail visible, would, of course, not render true color values.

Critical Frequency Relations in Scotopic Vision,[1] by Herbert E. Ives. If the eye is fixed upon a source of light before which a black revolving disc with openings in it periodically intercepts the light, for low speeds the revolution of the disc will be apparent as a "flickering" of the light's source. At very rapid speeds, no flicker will be apparent, the source of light appearing steady. There will be an intermediate speed at which the flicker just becomes apparent as the rotation of the disc is decreased and just disappears as its rotation is increased. The present paper is a study of certain phenomena of vision which are encountered in working with such flicker apparatus. The author shows that so long as the intensity of the light source is large enough to give color or "cone" vision, the critical speed at which flicker just appears, or disappears diminishes steadily as the intensity of the source of light is diminished. When the intensity has been reduced to the point at which "cone" vision disappears and only colorless or "rod" vision remains, the critical speed remains constant although the intensity of the light may be still very much reduced.

The relationship between critical speed and the shape, or wave form of the intercepting segments of the rotating disc is also discussed and an empirical relation arrived at.

The Voltage-Current relation in central anode Photo-Electric cells, by Herbert E. Ives and Thornton C. Fry. The paper supplies a theoretical discussion of the fact noted by one of the authors that in the case of some potassium cells, the voltage required to give the saturation value of the photo-electric current increases as the frequency of the light used to excite the emission is raised. The results of the analysis agree as to order of magnitude with observations to the effect that 40 volts and 160 volts were required in a certain photo-electric

[1]Journal of the Optical Society of America and Review of Scientific Instruments—Vol. 6, p. 254-268, May, 1922.

cell to give saturation for wave lengths 5500 A and 4500 A respectively. This effect should be taken into consideration whenever cells of the type specified are used to compare the intensities of radiations of different spectral distributions.

Philadelphia-Pittsburgh section of the New York-Chicago Cable,[1] by J. J. Pilliod. Engineering and construction features involved in a complete telephone cable system over 300 miles in length and connecting Philadelphia and Pittsburgh, Pa., are described in this paper. The cable is designed to operate as an extension of the Boston-Washington under-ground cable system with which it connects at Philadelphia. It is also designed for operation in connection with the Pittsburgh-Chicago cable now under construction, and other cable projects included in a comprehensive fundamental plan.

Beginning with the fundamental factor of public requirements for communication service between cities separated by various distances, there are next considered the methods available to provide this service. Small-gage, quadded, aerial cable, which was decided upon for use in this section after careful economic studies, is described in a general way and the important advantages of the application of loading and telephone repeaters are outlined. The use, in connection with this cable, of the recently developed metallic telegraph system for cables is referred to and some facts are given regarding power plants, test boards and buildings. A few of the many possible combinations of cable and equipment facilities into complete telephone circuits, each of which will furnish the required service in the most economical manner are illustrated.

The necessity of complete coordination of the many factors involved in a project of this kind is emphasized.

The relation of the Petersen System of Grounding Power networks to inductive effects in neighboring Communication

[1]See Bell System Tech. Journal, July 1922, and Journal of the A. I. E. E. August 1922

Circuits,[1] by H. M. Trueblood. This paper discusses, with reference particularly to its inductive interference aspects, a method of grounding power system neutrals due to W. Petersen, a German engineer. The distinctive feature of this system is the employment in the connection between neutral and ground, of an inductance adjusted to resonate at fundamental frequency with the total direct capacity of the system to ground. It is pointed out that this arrangement, proposed originally solely as a means of protecting the power system from the effects of accidental grounds, also possesses advantages of considerable importance from the standpoint of inductive interference. Chief among these are, first, the prevention of the large residual currents of fundamental frequency which occur in systems grounded through zero or a low impedance at times of accidental grounds, and which may induce high voltages in exposed circuits; and, second, the prevention, under normal operating conditions of triple harmonic residual voltages and currents which are frequently a troublesome source of noise in telephone circuits exposed to power circuits grounded in the manner common in this country. The paper also explains the characteristic action of the resonant system, by virtue of which the reactance coil functions as a protective device for the power system at times of accidental faults, and discusses the possibility of overvoltages at times of fault. A comparison in some detail of the Petersen system with other methods of grounding (including the non-grounded system), with respect both to fundamental and harmonic frequencies, is given.

The sensitivity and precision of the Electrostatic Transmitter for measuring sound intensities,[2] by E. C. Wente. The transmitter described is the same in principle as that described by the author in 1917 and now generally known, but certain changes have been made which render its sensitivity independent of changes in temperature,

[1]Bell System Technical Journal, July 1922; also Contribution from the Jefferson Physical Laboratory, Harvard University—Vol. 15, 1921-22.

[2]See Physical Review—Vol. 19, p. 498, May, 1922.

pressure and humidity. The sensitivity is also constant over long periods of time. Combined with an amplifier of ordinary design the transmitter has an overall sensitivity which is practically uniform from 25 to 8000 cycles. The apparatus can also be made highly selective and almost any desired sensitivity can be obtained by using a tuned amplifier in connection with a vibration galvanometer. The average sensitivity of the transmitter alone is about 0.35 millivolts per dyne per square centimeter.

A new type of High Power Vacuum Tube,[1] by Dr. W. Wilson. This paper describes two remarkably powerful water-cooled vacuum tubes which have been developed in the Bell System Research Laboratory. The small tube is capable of delivering about 10 kilowatts of high frequency energy and the larger tube, although less than three feet in length and weighing only ten pounds, is capable of generating 100 kilowatts. The principle of operation of the water-cooled tube is identical, from an electrical point of view, with that of the small tubes which are now so familiar as telephone repeaters and radio detectors, but their practicability has only been made possible by a new and striking development in the art of sealing metal to glass. To Mr. W. G. Houskeeper, of the Bell Laboratory, goes the credit for the development of the type of vacuum seals which are utilized in the new tubes.

[1]See Bell System Technical Journal—July 1922—Page 4.

Notes on Recent Occurrences

DEATH OF DR. ALEXANDER GRAHAM BELL

AMONG the most impressive of the tributes to the memory of Alexander Graham Bell, who died on August 2, was that of the telephone system which bears his name.

As the body of the inventor was being laid at rest on the summit of Beinn Breagh, near his summer home at Baddeck, Nova Scotia, on August 4, service was suspended for one minute on all lines of the American Telephone and Telegraph Company and its associated companies, both in the United States and Canada. There could be no more striking illustration of the importance of Bell's invention, or a more fitting testimonial to the regard in which his name is held by those who are carrying on the public service which he began, than that, in honor of the genius who first gave voice to the telephone, nearly 14,000,000 instruments—which trace their lineage to his first, crude device—should become momentarily silent.

Immediately upon receipt of the news of Dr. Bell's death H. B. Thayer, president of the American Telephone and Telegraph Company sent the following telegram to Mrs. Bell:

> "In behalf of all the men and women of the telephone system which bears his name, I extend our deepest sympathy and express our grief in the passing of Dr. Bell. History will record the inestimable value of his services to mankind, but we who are carrying on in the telephone art founded on his great discovery are peculiarly appreciative of his genius."

To this message Mrs. Bell replied:

> "Thank the men and women of the Bell Telephone System for their message of sympathy. The consideration and affection they have always shown him whenever occasion offered has always touched me deeply and is my comfort now."

Simultaneously with the sending of President Thayer's message it was directed that flags on all buildings through-

out the system should be flown at half-mast until after the funeral services.

Memorial resolutions were passed by the Directors of the American Telephone and Telegraph Company at a meeting held on August 15. Quite fittingly this tribute is recorded as coming, not merely from the Bell System as an organization, but on behalf of the hundreds of thousands of telephone workers of the world.

The resolutions follow:

> "In the death of Alexander Graham Bell the civilized world mourns for a man who thought fearlessly, worked tirelessly and served generously to relieve the unfortunate and to benefit humanity.
>
> "He was the inventor of the telephone because his thoughts adventured into new and untried fields of science, because his enthusiasm for discovery was sufficient to overcome all difficulties, because his practical mind demanded a consummation of his theories in practical results, and because he was inspired to contribute greatly to the common good.
>
> "As an investigator he was intelligent beyond the genius of his age. In the invention of the telephone he founded the art of transmitting speech electrically, a new and invaluable contribution to the humanizing of mankind.
>
> "He was one of the few in history who lived to see the child of his brain developed into a world-wide service. This was the only reward he sought and this reward was fully his.
>
> "Whereas, this company was founded upon and is devoted to the development of his invention for the service of humanity, it seems proper that we, the directors of the American Telephone and Telegraph Company, for ourselves and in behalf of the men and women of the Bell System, should spread upon our records our recognition of the debt owed to Alexander Graham Bell by the hundreds of thousands of telephone workers of the world for the opportunity for service which his invention made possible."

NINTH MEETING OF THE TELEPHONE PIONEERS OF AMERICA

THE ninth meeting of the Telephone Pioneers of America was held at Cleveland, Ohio, on September 29 and 30, 1922. Sixty delegates, representing nineteen chapters, and ten of the twelve officers attended the sessions of the General Assembly. Members of the

association and their relatives brought the total attendance up to 1200.

The organization has more than doubled its membership since the last meeting, the report of the secretary showing that since January 1, 1921, the enrollment has grown from 1742 to 4276, a net gain of 2534. The adoption, a year ago, of a new form of organization under which local chapters have been instituted in various sections of the country, has tended to increase interest in the work of the Pioneers. Twenty-one years of service in the telephone business is one of the requirements of membership.

The General Assembly which, under a constitutional amendment also passed a year ago, is the legislative body of the organization, adopted several important changes in the by-laws and elected officers for the coming year as follows: President, Leonard H. Kinnard, President of the Bell Telephone Company of Pennsylvania; Senior Vice-President, F. A. Stevenson, Director of the Long Lines Department, American Telephone and Telegraph Company; Vice-Presidents, James T. Moran, President of the Southern New England Telephone Company; J. A. Stewart, Vice-President of the New York Telephone Company, E. A. Reed, President of the Ohio Bell Telephone Company. The secretary and the treasurer are appointed by the executive committee.

Members elected to the Executive Committee for one year were B. A. Kaiser, American Telephone and Telegraph Company, and J. E. Warren, Southern Bell Telephone Company, while Verne Ray, Illinois Bell Telephone Company; Miss Mary Miller, Bell Telephone Company of Pennsylvania, and E. K. Hall, Vice-President of the American Telephone and Telegraph Company, were elected for two-year terms.

At the annual meeting of the association John J. Carty, the retiring president, made an address in which he paid an eloquent tribute to Dr. Alexander Graham Bell, inventor of the telephone. This address appears in full elsewhere in this issue of the QUARTERLY. The

association also took suitable action in memory of Dr. Bell.

One of the features of the gathering of the Pioneers was a meeting in the new Municipal Auditorium, at which a crowd of about 15,000 listened to a demonstration of the loud speaker, with "roll calls" of the repeater stations along the line between San Francisco and Havana, Cuba. Musical programs were presented at each end of the line. Newton D. Baker, former Secretary of War, and Mayor Fred H. Kohler of Cleveland addressed the audience.

An informal get-together dance, an outing at the Cleveland Yacht Club, at which the Pioneers were the luncheon guests of the Western Electric Company, and a delightful entertainment by employees of the Ohio Bell Telephone Company were other attractions. The banquet, an annual event at which the American Telephone and Telegraph Company acts as host to the Pioneers and their guests, was held at the Masonic Temple. General Carty presided and addresses were made by President H. B. Thayer of the A. T. & T. Co. and L. H. Kinnard, President-elect of the Pioneers organization.

DR. BELL'S APPRECIATION OF THE TELEPHONE SERVICE

AT the meeting of the Telephone Pioneers, the President, John J. Carty, read this letter from Mrs. Alexander Graham Bell, which shows that there is no foundation for the published rumor of Dr. Bell's dislike for the telephone.

"BEINN BHREAGH, NEAR BADDECK, N. S.

"*Dear Mr. Carty:*

"I am beginning to get distressed over the many statements the papers have been publishing of Mr. Bell's dislike of the telephone.

"Of course, he never had one in his study. That was where he went when he wanted to be alone with his

thoughts and his work. The telephone, of course, means intrusion by the outside world.

"And the little difficulties and delays often attending the establishment of conversation in even well managed telephone circuits did irritate him, so that as a rule he preferred having others send and receive messages. But all really important business over the telephone he transacted himself.

"There are few private houses more completely equipped with telephones than ours at 1331 Connecticut Avenue, and there was nothing that Mr. Bell was more particular about than our telephone service here. For nearly all of the thirty-five odd years we have been here he saw personally to its proper working. We never could have come here in the first place or continued here, but for the telephone which kept us in close touch with doctors and neighbors and the regular telegraph office.

"He saw to it that we should be able to reach that at any time, day or night. It was owing to this telephone system that we were able to come and stay up here last summer. Our physician lives sixty miles away in Sydney.

"I, myself, called him up at half-past five A.M. that last day; he answered immediately, and all through that day the telephone served Mr. Bell faithfully and well, bringing to him first one then another whom he called for. Afterwards the telegrams from all over came pouring in day and night—telephoned over without delay or mistake.

"It even accomplished what seemed almost impossible—the reaching of Mr. Charles Bell at Megantic Camp, Maine.

"There were relays, of course, but it was done by telephone—not from one big city to another—but from one isolated country station to another—from Canada to the United States.

"Mr. Bell did like to say in fun, 'Why did I ever invent the Telephone,' but no one had a higher appreciation of its indispensableness or used it more freely when need was—either personally or by deputy—and he was

really tremendously proud of it and all it was accomplishing. He appreciated the honor of being first to talk from New York to San Francisco, was awed by the wonder of its performance at that dinner at the New Willard, followed with interest its usefulness during the war, and the development shown at Arlington last autumn.

"Mr. Bell's one regret about the telephone was that his wife could not use it or follow his early work in sound.

"I honestly believe this had much to do with his not going on with the photophone experiments and engaging instead in aerial work the progress of which I could see as well as he.

"I shall always be so thankful that the telephone worked so well that last day—serving its father so loyally.

"Yours very sincerely,

"MABEL G. BELL.

"August 24, 1922."

PREFERRED STOCK ISSUE OF THE NEW YORK TELEPHONE COMPANY

THE New York Telephone Company recently offered $25,000,000 worth of its preferred stock to its subscribers. The subscription was open only one day. The amount offered was $82,500,000 and the applicants numbered 107,754.

Like similar issues offered during the past year by other Associated Companies of the Bell System, this issue was a preferred, cumulative stock, offered at par. Applicants were given the option of paying for their allotment in full or in monthly payments of $5 or multiples thereof, with interest at six per cent on installments as paid. The dividend rate on the issue is six and one half per cent.

A majority of the applicants elected the partial payment option and applications for small allotments predominated. Under the single payment option, there were 41,648 applications for a total of 470,268 shares.

The applications under the partial payment plan totaled 66,106 for 326,447 shares.

Applications for ten shares or less constituted over 70 per cent of those received, while over 60 per cent were for five shares or less. There were 22,124 applications for one share, 17,737 for two shares, 5,483 for three shares, 2,290 for four shares and 15,514 for five shares. The applications for from six to ten shares totaled 12,630, representing $12,091,500 and the applications from eleven to nineteen shares numbered 1,379 and represented $1,996,700. Applications for the maximum number of twenty shares numbered 24,609 and represented a par value of $49,218,000.

The allotment basis was:

1 to 2 shares inclusive	1 share
3 to 8 shares inclusive	2 shares
9 to 15 shares inclusive	3 shares
16 to 19 shares inclusive	4 shares
19 to 20 shares, inclusive	5 shares

Realizing that subscribers might be disappointed because of the cutting down of allotments and might wish to obtain stock for investment purposes, it was arranged to offer to them a number of shares of the stock of the American Telephone and Telegraph Company sufficient to enable each one to bring the total number of his shares up to the number he originally applied for. This stock was offered at the prevailing market price, to be paid for outright or in installments, as provided in the case of the original offer. Approximately 60,000 shares of the A. T. & T. Co. stock were applied for under this offer by over 9,500 persons.

NEW ISSUE OF AMERICAN TELEPHONE AND TELEGRAPH COMPANY STOCK

IN order to provide plant to meet existing and expected demands for service, the Directors of the American Telephone and Telegraph Company on August

24 offered to holders of record as of September 8, 1922, an issue of new common stock, on the basis of one share of new for each five shares outstanding. Upon this basis the amount to be offered will be approximately $115,000,000.

The purpose of the issue and the circumstances which prompted the decision of the Directors to offer it were explained in a statement of President H. B. Thayer which accompanied its announcement. He pointed out that the demand for telephone service shows no abatement, that the growth of the business provided an opportunity for the investment of additional funds, and that any further issue of stock was improbable for a considerable period to come.

Mr. Thayer said:

> "During the past two years of adverse business conditions the demand for telephone service has shown no abatement. During that periond there have been a million telephones added to the Bell System and there are now on file unfilled applications for about 200,000 telephones.
>
> "This continuing expansion of the telephone business requires additional plants and, in view of the prospects of better general business, even greater than normal growth is expected.
>
> "By a substantial issue of stock at this time the growth of the business for a considerable period to come will be provided for without further stock offering to stockholders.
>
> "The company is in funds to meet the balance now outstanding of its $50,000,000 note issue, due October 1, 1922, and the funds from the stock issue will provide for extension of the National telephone system."

In business and financial circles unusual interest was evinced in the company's announcement as indicative of the national business trend and it inspired much comment on the remarkable development of the telephone business and the soundness of telephone securities by reason of this development.

The privilege of subscribing for the new issue is evidenced by warrants for full shares or fractional shares, which have been mailed to stockholders of record as of September 8. Certificates of the new stock will be issued only upon warrants calling for full shares, but combina-

tions of rights for fractional shares may be made by their purchase and sale. The rights evidenced by the warrants may be transferred by assignment.

Payment for the shares subscribed for is to be made in three installments of $20, $40, and $40, on November 1, 1922, March 1, 1923 and July 2, 1923, interest at the rate of six per cent per annum on the respective payments from their due dates being allowed. The full amount may be paid on November 1, 1922 or March 1, 1923, with adjustments as to dividends and interest.

The subscription privilege closes on November 1, 1922.

EXPERIMENTAL BROADCASTING STATION NEW YORK CITY

IT was announced in the July number of the QUARTERLY that a license would probably be issued shortly for the new broadcasting station at 24 Walker Street, New York City. This license became effective July 25th and as expected permitted the station to operate during certain daylight hours and on Thursday evenings. This restricted time schedule was made necessary by the fact that the United States Department of Commerce was not ready at that time to issue a broadcasting license for other than 360 meters.

On October 2nd the original license was superseded by one granting permission to broadcast on 400 meters. As a result, a new time schedule has gone into effect assigning the afternoon hour from 4:30 to 5:30 every week-day and the evenings from 8 to 10 on Monday, Wednesday, Thursday and Saturday.

Beginning July 25th when the first license was issued, steps were taken to interest prospective users of these broadcasting facilities. The results obtained up to October 2nd were very encouraging but it was apparent that a license to operate only one night a week constituted a very real handicap to the building up of business. The new time schedule with permission to use

a wave length of 400 meters has materially improved this situation. With a desirable hour every afternoon and four evenings a week every effort will be made to popularize this new radio service, and it is expected that in the near future evidence will be at hand indicating how extensively it will be used by the public.